

AERO DIGEST

INCLUDING
AVIATION ENGINEERING

JANUARY 1955

50 CENTS

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CERMETS—A NEW SOLUTION FOR THERMAL SHOCK

PREDICTING FATIGUE FAILURES IN ALUMINUM
ALLOY STRUCTURES

DESIGN OF THE NORTHROP SCORPION

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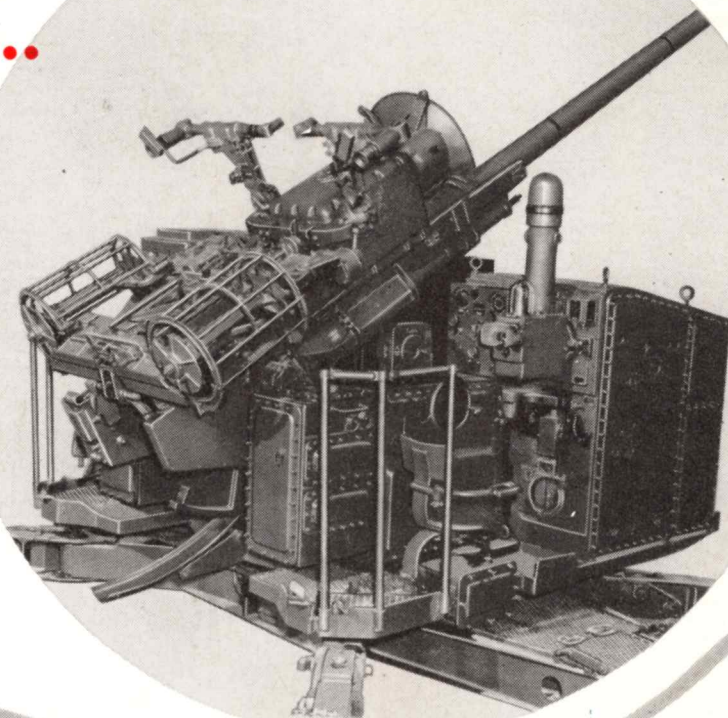
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This AC-developed machine reduced test time from 40 hours to 2 hours per unit



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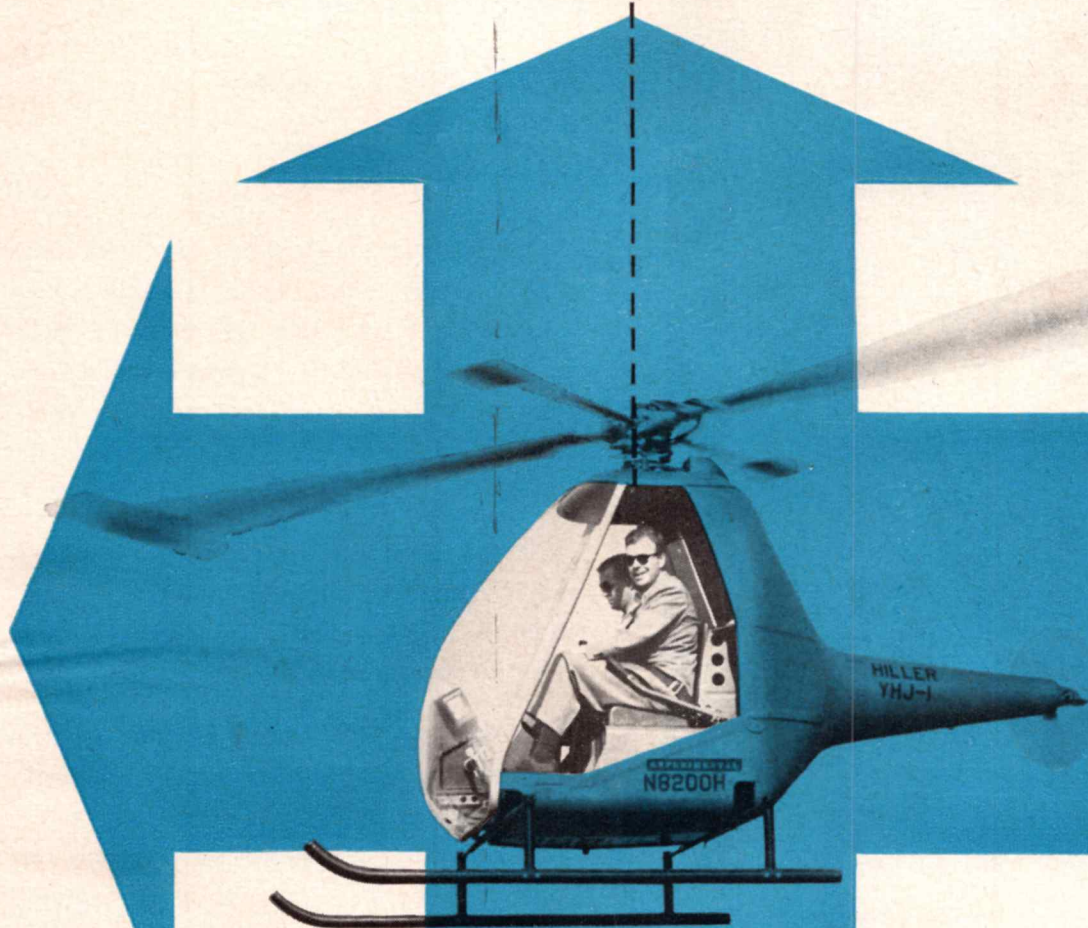
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IN THE HJ-1 HILLER RAM JET HELICOPTER

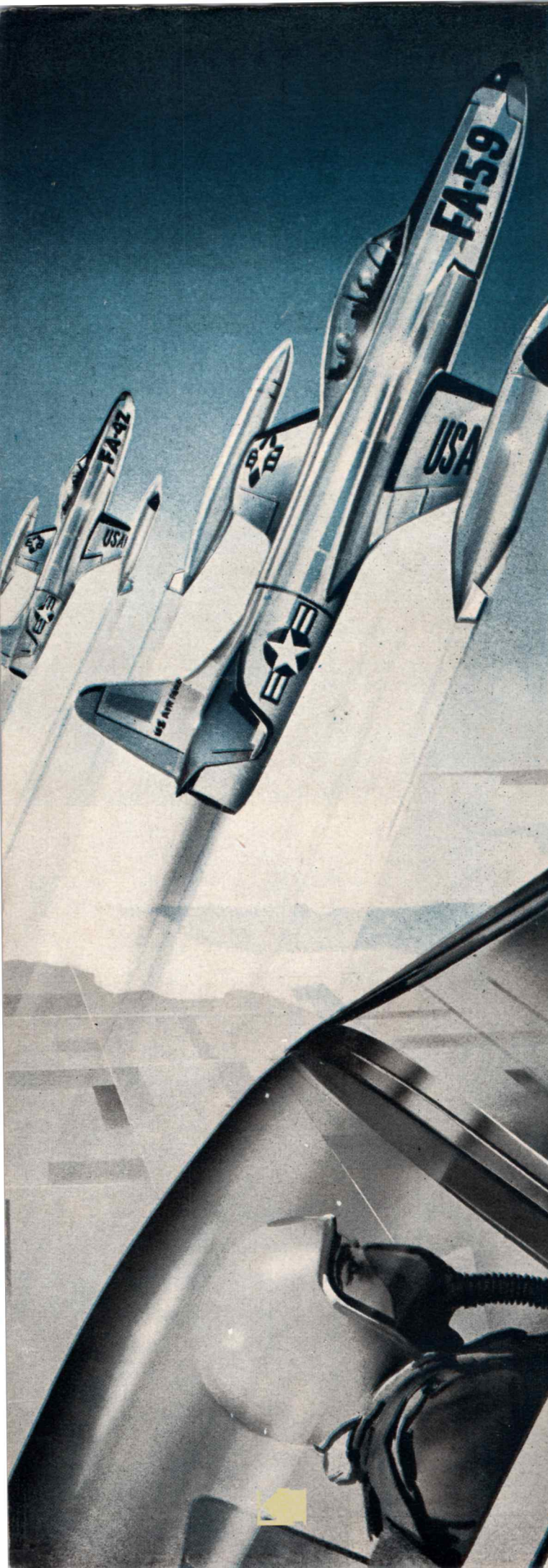


The Hiller HJ-1 helicopter

is powered by the first ram jet engine in the U. S. to receive C. A. A. certification. It is notable for its large transparent canopy, with the unusual visibility required for its large variety of missions, including training, liaison, reconnaissance, aerial photography and command. The HJ-1 canopy is an outstanding example of the optical perfection of Swedlow-produced components in transparent glazing materials. For specific applications, contact the Swedlow plant nearest you.

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100 Complicated Math Problems-Per-Minute Are Solved For Him **AUTOMATICALLY!**

As jet-powered planes streak to new altitudes and speeds, they undergo split-second changes in temperature, pressure and moisture conditions. These changes create a flood of amazingly complex fuel metering problems. Adding to the complication are the pilot's changing demands from his engine.

Solving these fuel metering problems is equivalent to solving one hundred computations every 60 seconds! The Holley Turbine Control was developed to do the job.

Manufacturing the Holley Turbine Control required highly specialized skills, too. Working to extreme tolerances, Holley's manufacturing division has produced precision turbine controls for thousands of the nation's jet engines.

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11955 NINE MILE ROAD
VAN DYKE, MICHIGAN

LEADER IN THE DESIGN, DEVELOPMENT AND MANUFACTURE OF AVIATION FUEL METERING DEVICES

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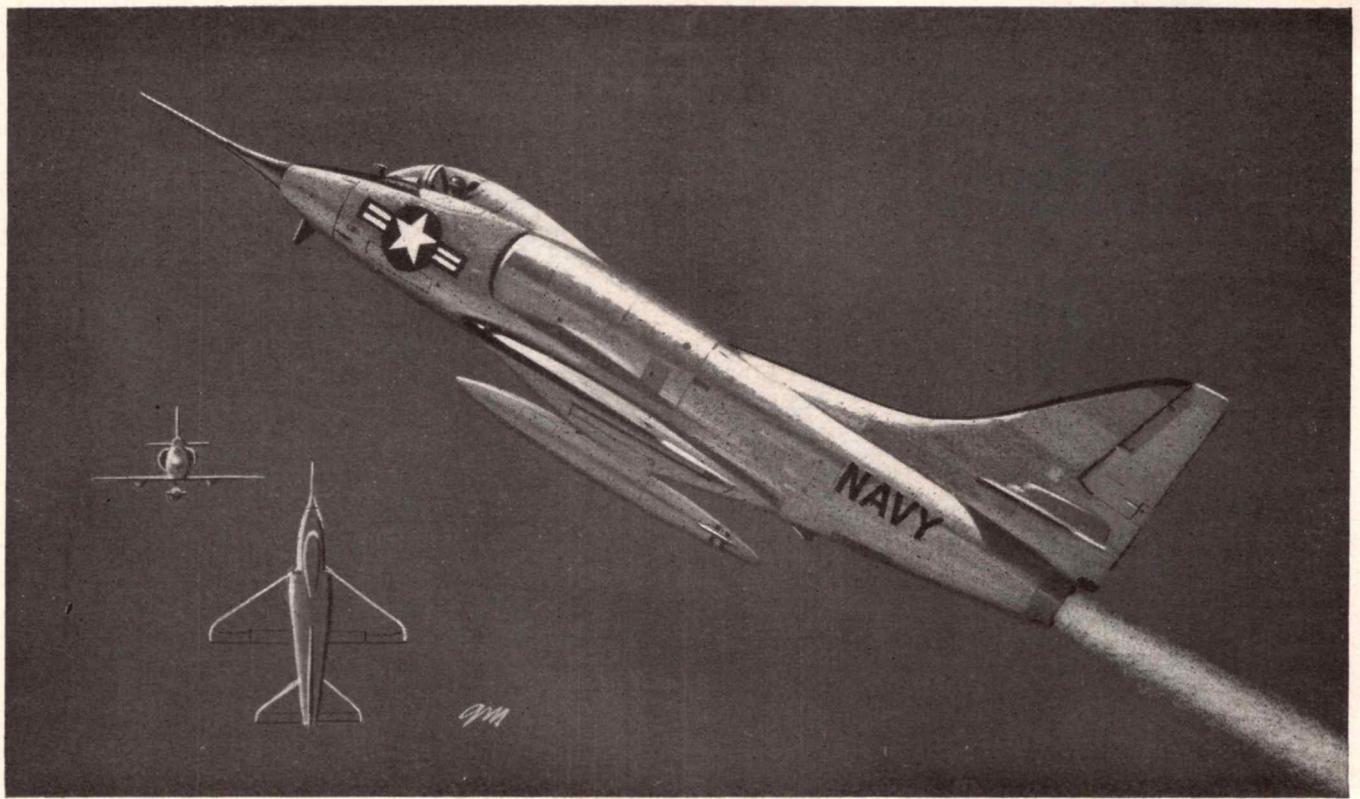
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U.S. Navy's A4D Skyhawk

U. S. Navy's one man bomber

The Skyhawk, *less than half the size of many current operational jet fighters*, is a revolutionary type of attack plane for the Navy. It's a "Mighty Midget" . . . capable of carrying atom bombs.

Powered by a Wright J65 Sapphire turbojet engine, the tiny Skyhawk can operate from carriers of all sizes. And its simplified lightweight design gives it a combat radius greater than many present propeller-driven attack planes.

Of its design, Edward H. Heinemann says, "We tried to integrate into the A4D the doctrine that by better engineering, airplanes can be built smaller and more efficient, as well as at considerably less cost and in shorter time."

Mr. Heinemann is chief engineer at the Douglas Aircraft Company's El Segundo, California, Division, where the Skyhawk is now in production.

In keeping with his philosophy of engineering, Inco Nickel and Inco Nickel Alloys are used in many parts essential to efficient and successful operation of the Skyhawk . . . used especially in *parts where strength and corrosion resistance at high temperatures are needed.*

In many other modern jet aircraft, too, you find that Inco Nickel Alloys supply outstanding properties for difficult service. Perhaps one of these alloys can solve your metal problem. Inco's Technical Service Section is ready to help you investigate. Write us.

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AERO NEWS DIGEST

THE SHORTAGE OF ENGINEERS, made the more serious by recent reports that the Russians are staging an all-out campaign to increase their supply (see page 21), has also led to some plain and fancy competitive efforts to sign up new talent among aircraft companies. Our latest word from the field, received too near deadline for a check-up, is that one big outfit now figures it costs a minimum of \$10,000 to get one good engineer on the payroll. So the organization conducted a blitz recruitment campaign, using television. Leads that resulted were followed up by top executives in the company, who called on candidates personally at their homes.

SUCH BEING THE CASE, some of the lowpay government agencies hiring engineering talent are being raided with increasing intensity. Recruitment among these Federal agencies is also difficult by the same token. The National Advisory Committee for Aeronautics estimated recently that they can offer from \$800 to \$1200 less than competing private enterprises for young graduates with Bachelor of Science degrees. NACA's starting pay today for a BS graduate is \$3,400.

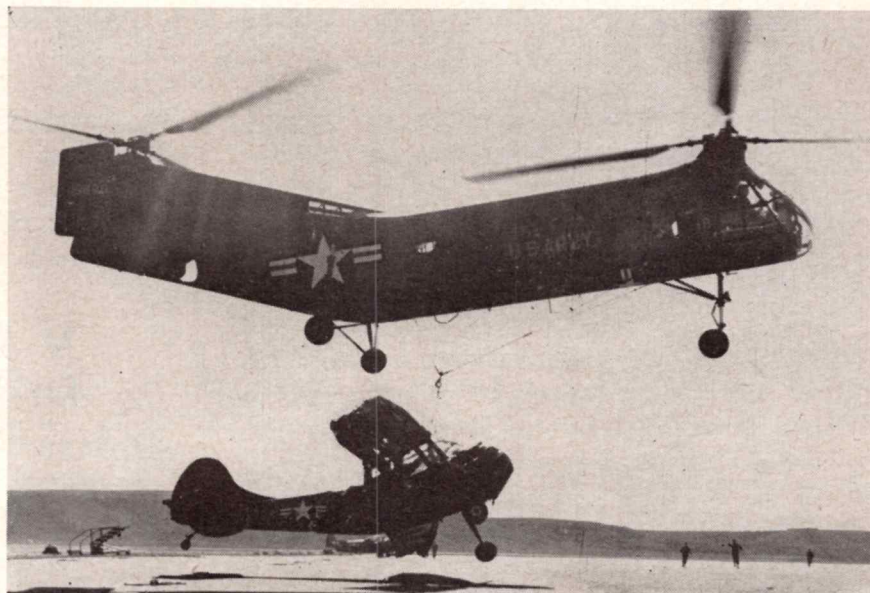
ANOTHER SHORTAGE SIDE-LIGHT that came up in the news this month was revealed by *Washington Post* Aviation Editor John G. Norris. Norris gave an impressive report of the Air University, Maxwell Air Force Base, Montgomery, Ga. To protect his sources, he buried the news deep in the account. Steps to improve the University, he said, "are piecemeal." Reason? "What's basically wrong with the Air Force educational program—though University General Laurence S. Kuter and his aides won't say so—is the military economy program." It has cut University activities to the bone—with threats of more cuts to come.

COUNT ON THESE AND OTHER "economies" to get a thorough airing during the coming session of the Congress. Predictions by all observers are that the Democrats are going to be particularly caustic in criticism of Defense Secretary Wilson's savings. More funds for the Air Force and its industrial base are undoubtedly going to be proposed. How far they will get, despite Democratic control, is another question, weighted somewhat on the international climate when voting time comes.

ALSO HARD-HIT by the manpower situation, and threatened with ever more severe conditions, is Air Force recruitment. Pilot shortages are showing up in all flying units. The Strategic Air Command, already suffering severe damage, faces the new year with a threatened loss of more than 55 percent of its trained men. Recruitment is becoming equally difficult. Considering the cost of training a man, the whole situation, according to best Air Force estimates, results in a loss on the order of a billion dollars annually. That's why Brigadier General Arno

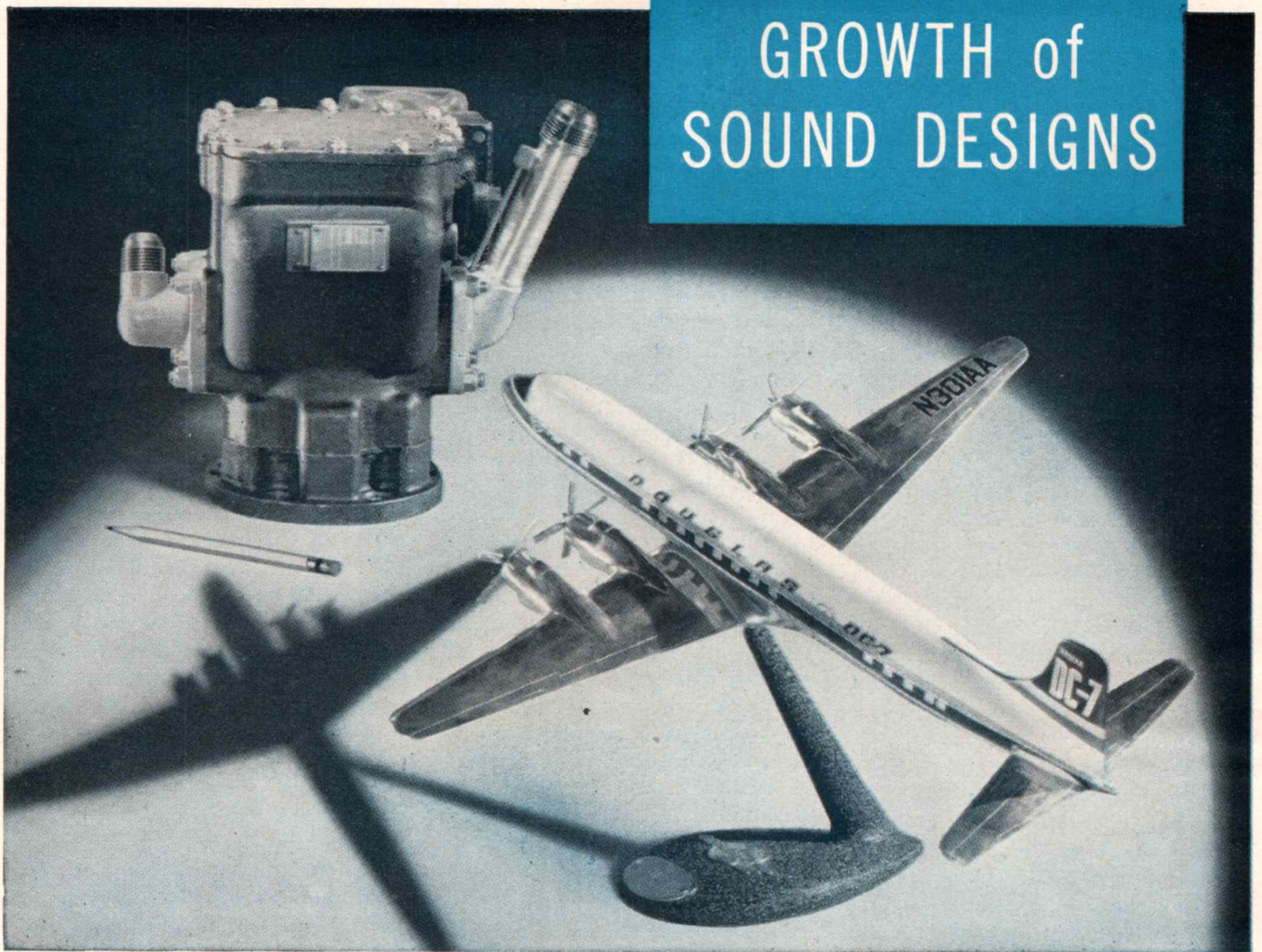
H. Leuhman has been given full-throttle backing by the Air Force to push recruitment. And it is also why Defense Secretary Wilson, economies or no, is expected to fight the Congress for pay boosts for all military personnel, at an estimated cost of more than half a billion dollars.

AS PREDICTED in this column in November, the road that the small business man must travel in the defense program is not smooth, and latest word is that it will be another six months before even complete facts are available. That is the meaning behind current Congressional prodding of the Pentagon for more adequate reporting on small business programs. Both House and Senate have repeatedly asked Defense to give figures on the volume of contracts awarded to small businesses. To date, these reports have been either inadequate, evasive or both. Goal of the Congress is to install better reporting procedures by the end of this fiscal year, June 30, and meetings toward that end are scheduled on the Hill beginning this month.



A Piasecki-built Army H-21C helicopter returns an ill-fated L-19 to its home base after picking the plane off a sand bar in the Kansas River.

GROWTH of SOUND DESIGNS



New DOUGLAS DC-7 Uses New **VICKERS**[®] Variable Displacement Hydraulic Pumps

Cabin supercharger drives on the new Douglas DC-7 use the largest known variable delivery aircraft hydraulic pump . . . the new Vickers PV-3918. Like the DC-7, the PV-3918 is an outgrowth of previous successful designs.

This pump is a development from similar but smaller pumps used in the DC-6, DC-6A and DC-6B. The basic application was so successful it was adopted for the new DC-7. The new pump provides a 147% increase in flow capacity with only a 50% increase in weight. A special feature of the PV-3918 is an overspeed control which automatically limits the maximum pump delivery

and accordingly provides another safety check on compressor impeller speed.

For further information about the numerous advantages of Vickers Variable Displacement Piston Type Pumps, ask for Bulletin A-5203.

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

AIR FORCE is suffering most pressure on the reporting problem, which may lead to a more rapid solution than for other services. Thus spurred, the AF is staging a series of meetings with industry. They are shooting for sub-contracting, small-business statistics on a regular schedule from as many as 500 prime contractors—five times as many as are reporting today. Meantime, Air Force reports that out of 104,000 firms capable of producing Air Force items, 101,000 have been classified as small business. But while these contractors got some 30 percent of the prime business in 1953, in fiscal '54 it was only 20 percent. Best guesstimates are that the percentages will be even smaller this fiscal year.

GOOD NEWS for armament manufacturers—the Defense Department is going to ask for more money for guided missiles and rockets in its 1956 fiscal year budget. If the money is granted, increased sums will go for research and development in the guided missile field.

JET ENGINE BLADES are getting a "two-way" stretch in a new General Electric testing machine. End tension is put in by an 18-ton spring, and vibrations by a rocker. A camera is mounted over an oscilloscope in order to keep a photographic record of the tests.

LATEST WIND TUNNEL NEWS includes word from Minneapolis where a privately financed supersonic tunnel of the blowdown type has been erected by the Fluidyne Engineering Corporation. Tunnel will be used in research and development programs that the company conducts for the aircraft industry and the armed services. The new tunnel has test section dimensions of 14" x 14" and can operate over the Mach number range from 1.5 to 5.5. Already in operation is a smaller supersonic tunnel in which the company is investigating recovery and drag of air inlet systems, development of variable geometry nozzles, investigations of aircraft control surfaces, development of compressor compo-

nents, and tests of emergency airborne generators. . . . March, 1956, should see North American Aircraft celebrating the completion of its \$5-million intermittent blowdown type wind tunnel. Construction started late in 1954. The tunnel is designed to take models up to four feet wide and run up to speeds of Mach 3.5.

A NOW-IT-CAN-BE-TOLD story concerns flight of an airplane controlled by an all-transistor autopilot—one of the first to be designed without using a single electron tube. According to R. P. Lansing, Vice President and group executive of Bendix Aviation Corporation, designers of the autopilot, plans now call for it to be used in a Lockheed F-94C.

AIR FORCE PILOTS will be wearing new headgear this spring, if ARDC's Wright Air Development Center has anything to say about the matter. With the development of a lightweight fibreglass helmet by the Center and industry, the cotton duck helmet will be on its way out.

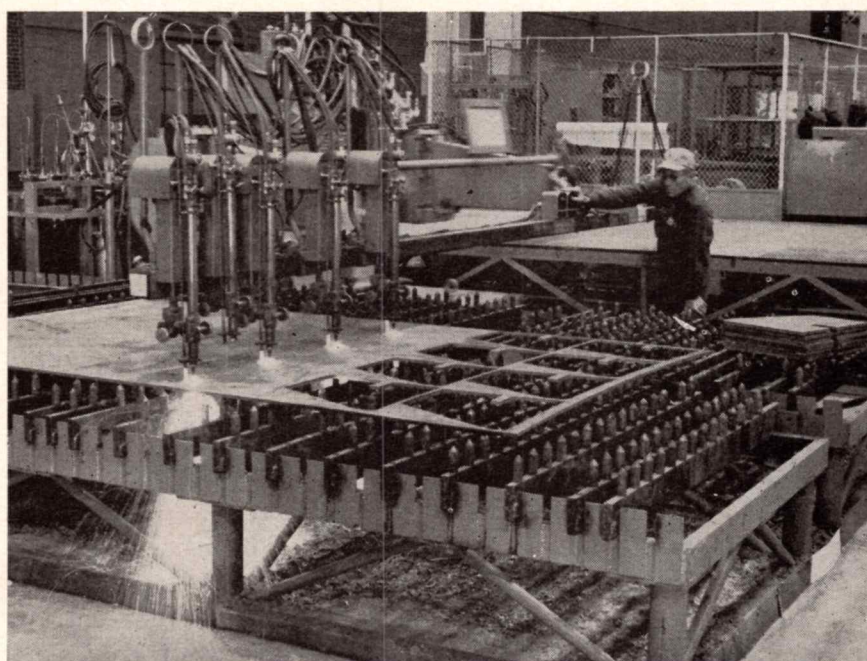
SIX METEOROLOGISTS at United Air Lines' Long Range Flight Advisory Unit said they knew it all the time when Captain R. F.

Dawson recently flew his DC-7 non-stop from San Francisco to New York in new record time. In fact, they knew it beforehand. They gave him the wind data.

NOBODY will say how long it will be before private citizens will buy and fly one-man helicopters, but a one-man Marine Corps helicopter competition has been won by Gyrodyne Company of America, St. James, N. Y., and by Hiller Helicopters, Palo Alto, Calif. Research and development contracts worth \$200,000 were awarded each company by the Navy. Contracts have a year to run and call for the design of a lightweight rotorcraft for one-man tactical maneuvers.

IN THE SKIES right now is a new series of Super Constellation radar picket planes flying for deliveries to the Air Force. Designated RC-121D, they differ from earlier Super Constellations in that they have added two 600-gallon wingtip fuel tanks and a 1000-gallon fuselage tank. Fuel capacity totals 8750 gallons, 2200 gallons more than earlier models.

CURTISS-WRIGHT has come up with a rocket throttle. Now instead of dropping from full



Fiery jets cut through half-inch steel plate and make four identical cut-outs simultaneously at Boeing Airplane Company's Wichita, Kan., Division where the Travograph flame cutter has demonstrated a high degree of speed, accuracy and economy.

power to zero power in a matter of five minutes (4.2 minutes for the Bell X-1A in which Yeager went 1650 mph), the new engine can dole out energy in accordance with a flight plan. Reports are that the first job for the throttle engine will be on the Bell X-2, said to be designed for Mach 3 speeds.

IT'S SCHOOL DAYS again for some of Minneapolis-Honeywell's executives. They're being taught the art of dictating letters without the aid and comfort of cigar-chewing,

pipe-puffing, or ceiling-inspecting. Short words are preferred to long ones, simple sentences (21 to 30 words) rather than involved ones. The goal? Simply letters that will be understood.

THE AIR FORCE is going to get a twin-jet bomber-trainer from Glenn L. Martin. According to the contract, this will be a transition trainer aircraft equipped with dual controls. It will be the fourth version of the company's B-57 light bomber, which is now in production.

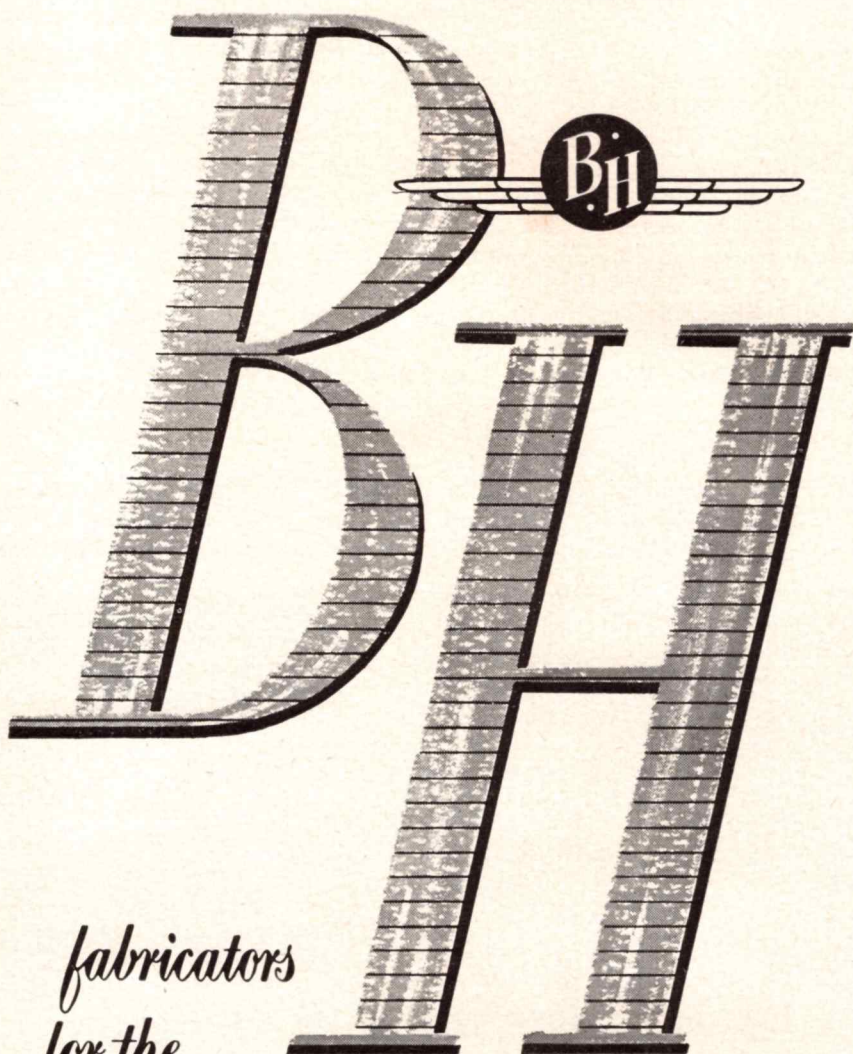
ONE OF THE MOST significant statements made at the recent A. S. M. E. Thermal Barrier Conference was by Professor N. J. Hoff, Polytechnic Institute of Brooklyn: "Perhaps the most novel feature of the behavior of structures at high temperatures is the time-dependence of failure. Both in tension and compression the structural element fails under any load if it is maintained for a sufficiently long time. In this respect structures at high temperatures differ fundamentally from those used only at ordinary temperatures. The designer of supersonic aircraft has to get used to the idea that *each structural element must be calculated for a definite lifetime.*"

LAST MINUTE NEWS from Douglas says that the average worker in aircraft is getting almost \$1000 a year more today than he was when the Korean War started in July, 1950, bringing his wage to \$726 higher than today's average wage in manufacturing.

THE WORD IS OUT for a high-payload turboprop transport to aid the nation in its air logistics problems. At an Air Force Association sponsored meeting in Washington last month, nearly one thousand top-line officials from industry, airlines, and the government were told that we needed aircraft that could lug 100,000 pounds between the United States and the country's overseas bases, aircraft that wouldn't have to stop to refuel, and that would cruise at about 500 mph.

SEEMS THAT WE'VE spent so much time developing and building jets for fighter-type aircraft to meet enemy threats, that we have lost sight of the logistics problems. But the experience we've gained in jet engines could be used to design the required turboprops which at least would solve the powerplant phase of the problem.

Considering a hypothetical airplane with a payload between 25,000 and 50,000 pounds, American airlines president C. R. Smith called for the military and the carriers to standardize on such an aircraft in order to bring the cost down to reason, told the



*fabricators
for the
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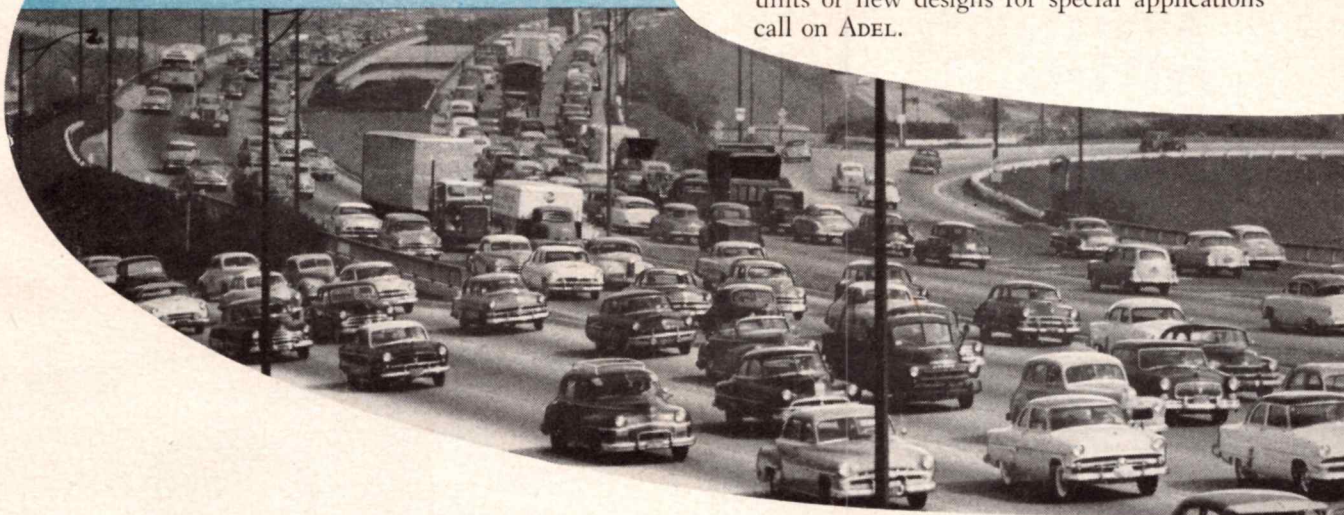
ADEL SAFETY... rides with every flight!



Skyways are Safeways

According to a survey just completed, it is more than five times safer to take a trip by scheduled airliner than by car. ADEL has contributed to this remarkable safety record by creating over 600 different components for every type of aircraft application, all engineered and produced to incredibly close tolerances to give aircraft the added assurance of units that *exceed* the exacting requirements of performance and endurance.

The giant transports of the nation's domestic and international airlines last year established their best safety record in history, carrying 31 million passengers more than 20 billion passenger miles. This is positive proof that the most dangerous thing about *flying* is *driving* to the airport. For dependable standard aircraft units or new designs for special applications call on ADEL.

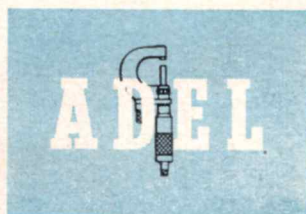


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FUEL SYSTEM EQUIPMENT



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LINE SUPPORTS



JANUARY 1955



NEW SERVICE STARTS—Hostesses of five airlines—United, Western, Pan American, American and TWA—cut a ribbon to open Los Angeles Airways' first helicopter

passenger route after eight years of scheduled mail operations. First passenger service is between Long Beach and Los Angeles International Airport, with Sikorsky S-55s.

AROUND THE WORLD WITH SIKORSKY HELICOPTERS



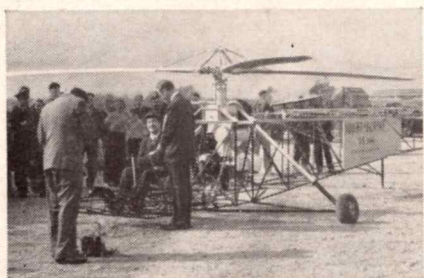
RCAF SIKORSKYS—First all-helicopter squadron in the Royal Canadian Air Force is now in operation with rugged Sikorsky S-55s. These wilderness-proved transport helicopters are now based at Bagotville, Quebec. Here are four of ten S-55s in the initial Canadian order. All were flown to Canada from Sikorsky's plant.



BRITISH USE S-55s—Helicopter passenger service between London Airport and Waterloo is scheduled to begin this spring. British European Airways will use S-55s for the flights, which take 18 minutes each way compared to more than an hour by surface travel. BEA pioneered helicopter passenger flights in 1950 with S-51s.



America's First Truly Successful Helicopter —Sikorsky VS-300



MAY 20, 1940—First public view of Sikorsky's historic VS-300—America's first truly successful helicopter—came May 20, 1940 as Igor Sikorsky was awarded Helicopter Pilot License No. 1. The VS-300 was only the first of many Sikorsky achievements in advancing helicopter development and industry-leading production efficiency.

SERVICE EXPANDS—New York Airways has expanded scheduled helicopter passenger service both north and south from its New York City inter-airport routes. Cities added were Trenton and New Brunswick, New Jersey, on the south, and suburban White Plains, New York, and Stamford, Conn., on the north. Above, passengers board a Sikorsky S-55 at the heliport in Stamford.



SIKORSKY AIRCRAFT

BRIDGEPORT, CONNECTICUT

One of the Divisions of United Aircraft Corporation

military they were carrying the ball and to start running with it; the airlines would support such a program.

Aerocast, Washington, says to expect the Army to call for 1000 tanker planes, which includes 520 heli-tankers, during the 1950-1970 decade to support air operation in depth. Conclusions are based on anticipated use of atomic weapons. Study ends with the observation that "continental land masses may best be considered as oceans of highly developed industrial, strategic and military complexes—the control of which by island-hopping airhead attacks will assure early and less costly decisions. The supply of such mobile forces can be resolved only by air logistics including the tanker plane and heli-tanker capable of direct fuel supply to forward ground units anywhere at anytime."

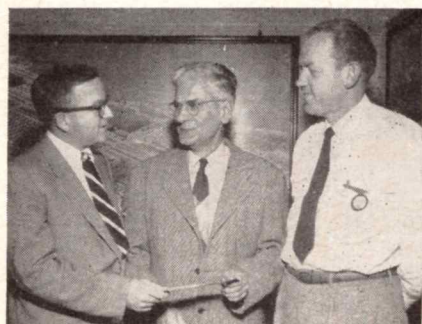
FRED HAMLIN



Anthony J. Sisti of Buffalo, N. Y. has the distinction of being the first artist to be aloft in a helicopter to draw sketches. While he hovers in a Bell Model 47G helicopter, Sisti makes pencil sketches of a high level bridge under construction near downtown Buffalo.

DESIGN FORUM

Grand Prize Awards Will Be Announced in February



Alfred E. Blatter, Rohr Aircraft, winner of December Design Forum contest, receives first prize check.

Since last August, AERO DIGEST has been sponsoring *Design Forum*. In this way, the magazine has recognized and encouraged achievements of engineers and technicians who through their entire proposed award-winning means of improving flight safety, reducing airplane com-

plexity, and providing manufacturing cost savings.

Grand prize winners will be announced at time of publication of the February, 1955 issue of AERO DIGEST. Decisions of the judges shall be final. The judges are:

Dr. Max Munk, Chairman of the Department of Aeronautical Engineering, Catholic University,

R. J. Sandstrom, Vice-President, Engineering, Bell Aircraft Corporation,

A. A. Vollmecke, Chief, Airframe and Equipment Branch, Civil Aeronautics Administration,

William Beller, Managing Editor, AERO DIGEST.

The \$2625 being awarded will be divided as follows: First prize: \$1000, Second prize: \$750, Third

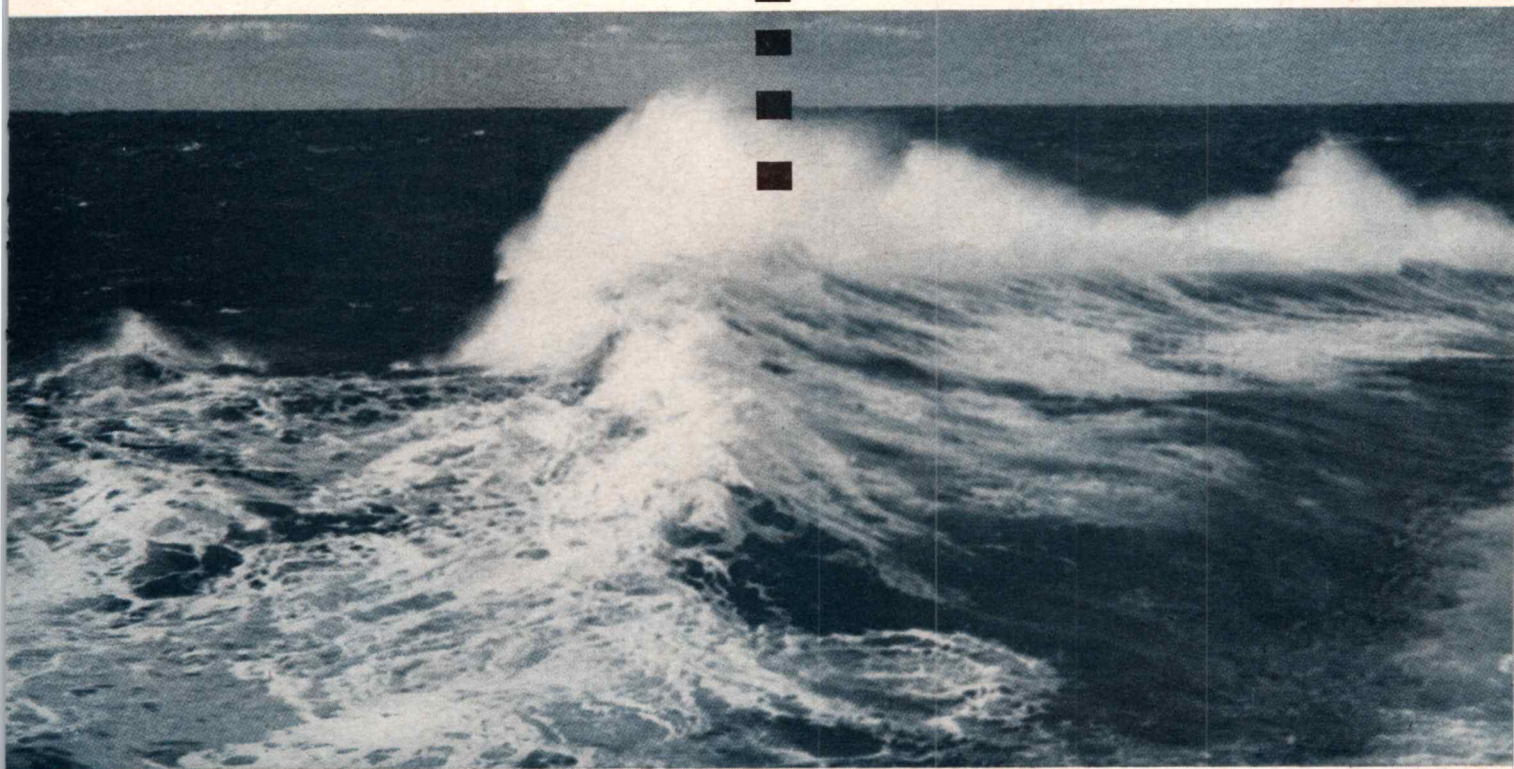
prize: \$500, Three honorable mentions, \$125 each.

All entries, regardless of when received or whether they win a monthly award, qualify for grand prizes if mailed by midnight, Dec. 1, 1954.



S. E. Black, Hughes Aircraft Missile Division is presented his second prize award for December contest.

TOP SECRET



You see here the next great area in the rocketing progress of flight...a study in deep blue of three-fourths of our world.

To those behind the scenes, the picture says this:

Today at Martin, one of the most important airplanes in the world is about to be officially unveiled. It is the United States Navy's great new XP6M—ship No. 1 and prototype of an entirely new concept in air power, which may well launch a new era in American security and supremacy in the air.

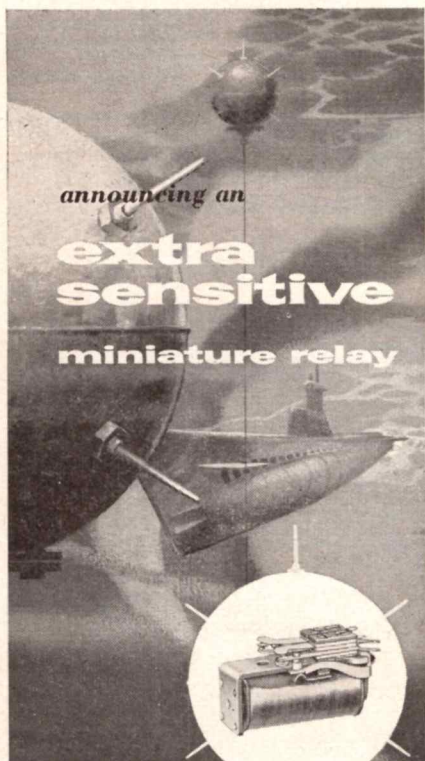
For the rivers, lakes, and seas of the world offer countless free and indestructible bases for the swift deployment of troops, armament and materiel... "bases unlimited," within sight from the air of virtually every spot on this earth!

The Martin XP6M is a water-based aircraft, powered for unbelievable speed, and a basic design adaptable to a variety of top-priority functions.

Its name, appropriately, is The SeaMaster. Its dominion: three-fourths of our world.

MARTIN
BALTIMORE · MARYLAND





It's the new ADVANCE SQ—a telephone type that hits a new high in ruggedness and efficiency!

Only 15 milliwatts per pole will operate the new SQ relay in the DPDT combination. Here is sensitivity teamed with stable performance—the DPDT unit withstands 10 G's vibration from 10 to 500 cycles. When power is increased to 40 milliwatts per pole, vibration resistance rises to 30 G's. A single-coil relay, the ADVANCE SQ is available in 1- to 5-amp contact ratings, and in contact combinations from SPST to 6PDT. It comes through Signal Corps tumbling and shock tests in excess of 200 G's with operating characteristics unimpaired.

Sustained efficiency keynotes SQ operation. The use of a beryllium copper armature retaining spring insures positive contact between armature and pivot points at all times. Cross-bar palladium contacts are always properly aligned. A wide variety of coil resistances is feasible. Instead of organic insulation, the unit employs Silicone glass, Kel-F, or Teflon tubing. Life expectancy for 5-amp, non-inductive loads is 150,000 cycles... for 1-amp, non-inductive load: 1,000,000 cycles.

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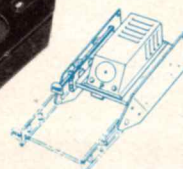
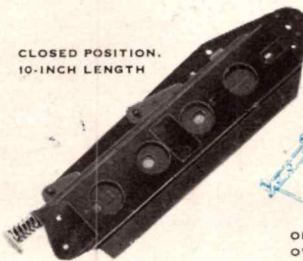
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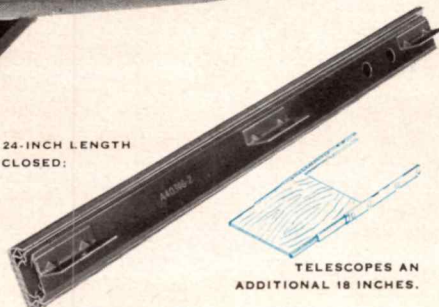


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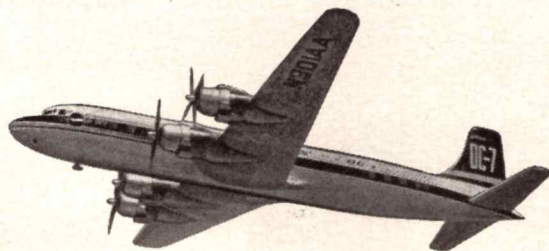
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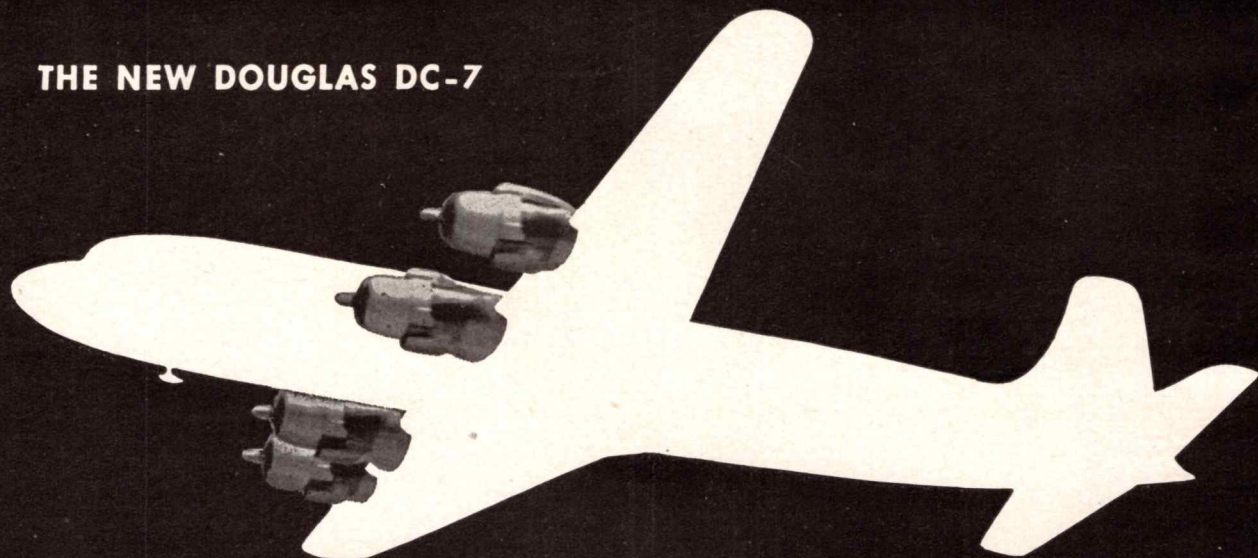
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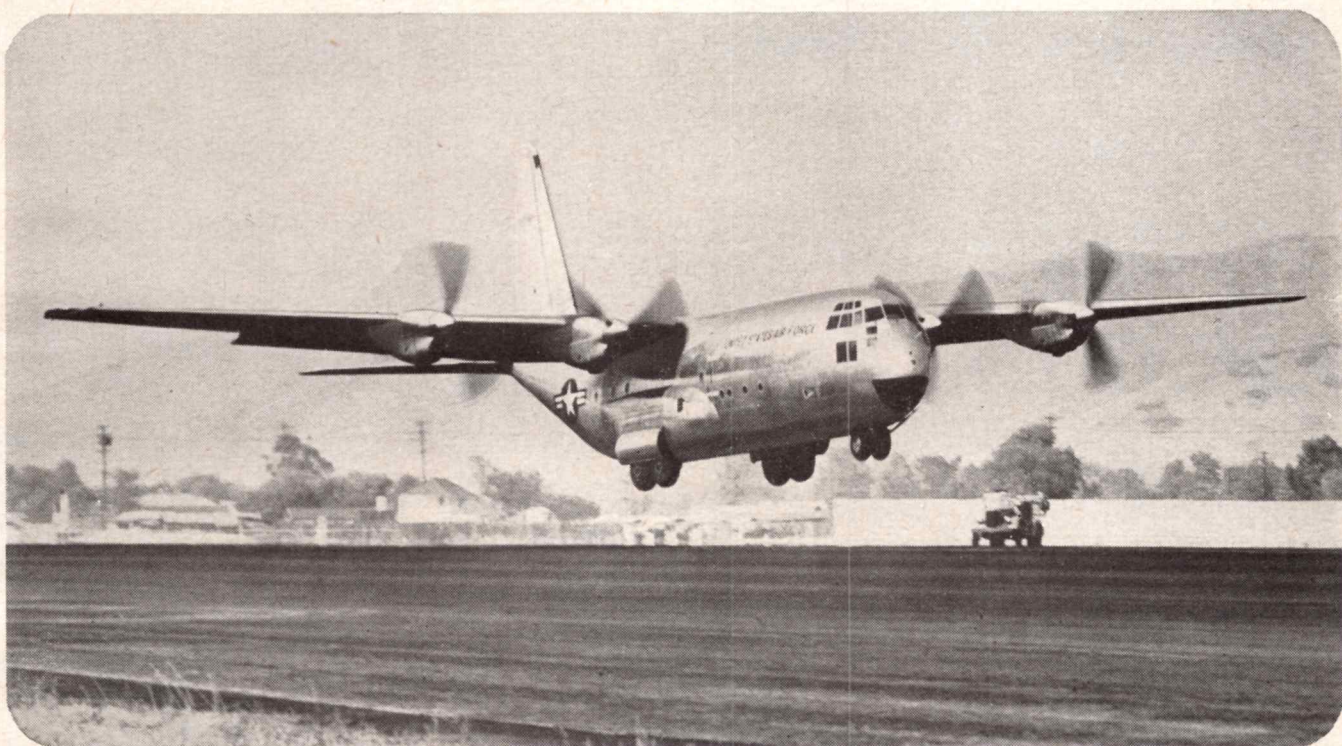
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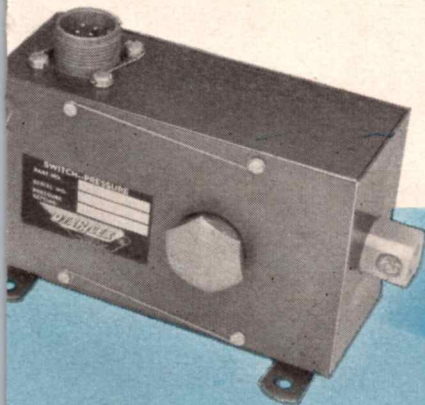
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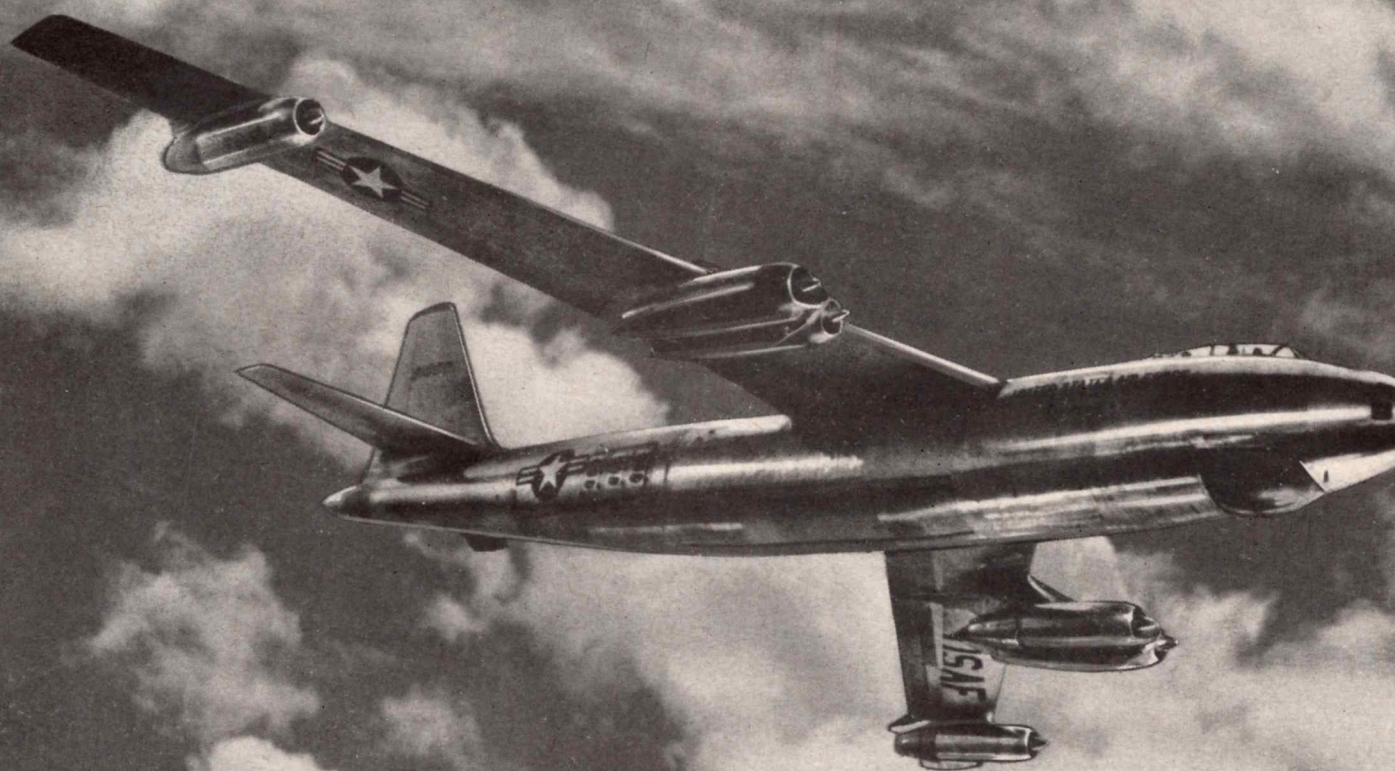
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AN EDITORIAL

THE BATTLE FOR BRAINS

AERO DIGEST

America's Premier Aeronautical Magazine

Vol. 70 No. 1 January 1955

COLDEST FACT IN THE COLD WAR is that the United States is losing a world's championship title which up to now has never been challenged.

Unequalled for our know-how, we are being challenged by the Russians so strongly that, if something isn't done about it—and soon—they will become the champs. And if we lose, and peace continues, we will not win our position back for years; perhaps never in case of war.

The Russian attack is being made by using manpower of all ages, from grade school to retirement. Youngsters are encouraged to excel in technical subjects. Teachers are at the same time encouraged to stay in technical fields. Every advantage is offered students at the college level showing an aptitude in any engineering field, and engineering as a career gets the sustained support of the Government. Already the Soviets are graduating more than twice as many engineers as are being turned out by our colleges and universities. Total number of Soviet engineers today equals if not exceeds ours, and will inevitably far outnumber ours if we do not do something about it.

At first glance, a great deal is being done. The Congress has held a series of hearings on the problem. Selective Service regulations, considered by many a bane, come up for revision this spring. Perhaps before this is in print, a Presidential Cabinet Committee will make public a report on how to train more and better scientists and engineers. The aircraft industry, for one, is saving millions of engineering manhours and dollars by streamlining engineering work and routing as much routine as possible to non-engineering workers.

But these are only nibbles at the edge of the major problem—to meet the growing need for highly trained

technicians. This is most evident in the aircraft and allied industries, where the first production model of a typical new jet requires 1.3-million engineering manhours, compared with some 110,000 for a World War II fighter.

And as the demand increases, the supply drops off.

There is obviously no quick-and-easy solution to the problem, as the President's Committee, among others, are agreed. They are also expected to report, surprisingly, that economics is not the major barrier to becoming an engineer. The biggest basic road block, the Committee find, is lack of encouragement to youngsters to gain a scientific interest and build a scientific foundation at the high school level. Linked closely with this is the lack of adequate high school teachers in the technical fields, threatening to become more acute. Fewer students are attracted to the low-pay high school teaching jobs, and those who do turn to teaching are often soon lured away by higher-pay, better-opportunity industrial jobs.

The Russians have an easy cure for these ills. They tell the kiddies to concentrate on scientific subjects or else, and assign enough teachers to do the job, regardless of salary.

Such methods are inconceivable in a democracy. But an all-out campaign, citing the seriousness of the situation and driving toward correcting it at the local, high school level, should result in needed changes. Industry can solve this, its most serious problem, not by wrangling over details and pirating engineers, but by educating the public to the cold-war fact that they alone can solve the problem through the schools.

It is a campaign that is long overdue. America must remain the world's arsenal of know-how, and only a concerted national effort can achieve this goal.

CERMETS

A NEW SOLUTION FOR THERMAL SHOCK

Part metal, part nonmetal, this composite resists high temperatures better than ceramics,

can be made by conventional means, and

has predictable physical properties.

By J. A. STAVROLAKIS

Supervisor, Ceramics Section
Armour Research Foundation, Illinois
Institute of Technology, Chicago

Fig. 2—High pressure hydrostatic die for pressing cermet powders.

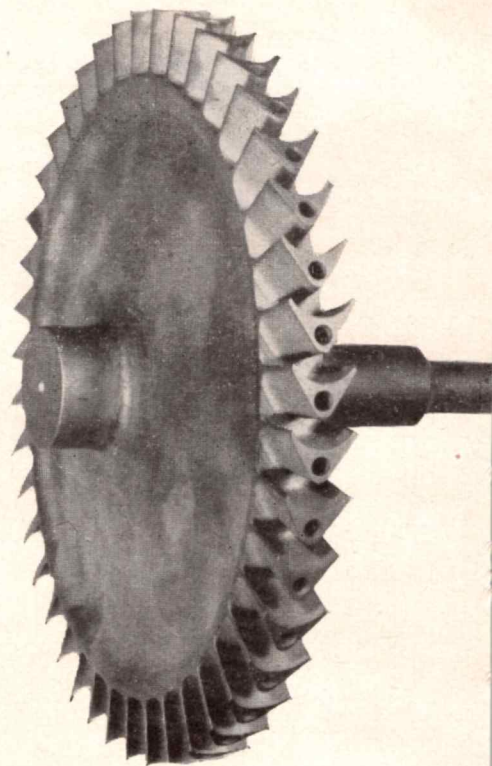
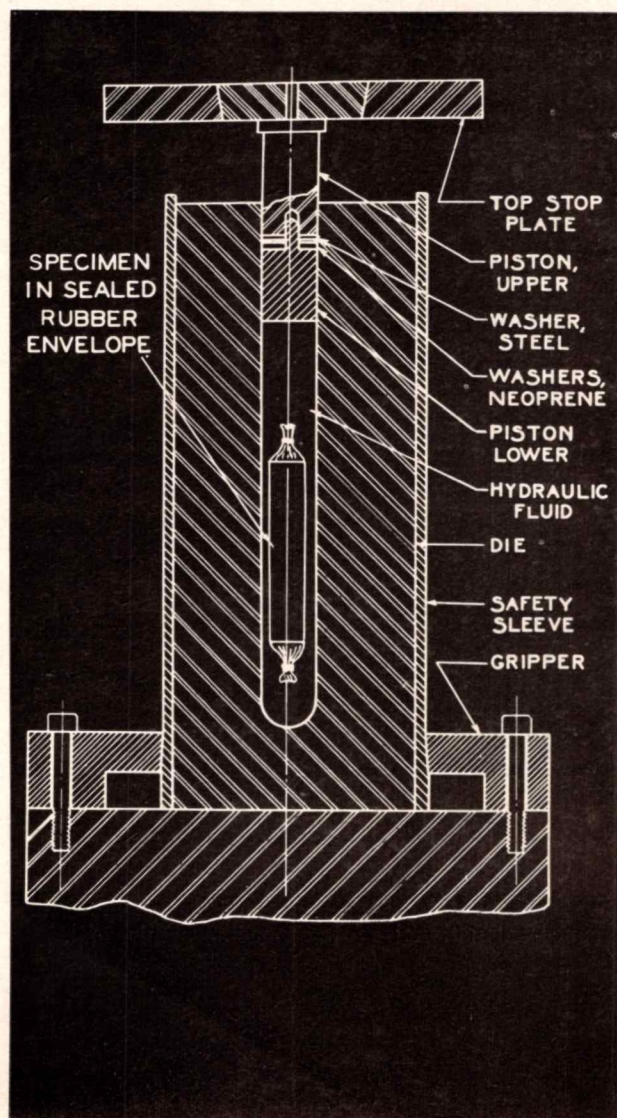


Fig. 1—Turbine rotor of titanium carbide cermet.

CERMETS—composites that do not fit into the classical definition of metals or nonmetals—are becoming a major factor in making jet engines. The material surpasses ceramic materials in resisting thermal shock.

Fig. 1 illustrates a rotor of titanium carbide. Important potential uses are in the manufacture of rocket nozzles and directional fins, and for valves of high-powered reciprocating aircraft engines. Also, cermets may be used to form the burner cones in gas turbine combustion chambers.

Thermocouple protection tubes of an alumina cermet are on the market. Mill guides of titanium carbide are being used in some of the country's largest rod producers for rolling AISI 1010, 1020, and various other grades of alloy wire rod. Production downtime is markedly reduced and scrap generation is decreased by 80 percent. In addition, cermets are being utilized as exhaust and intake valve seats, high-temperature water bearings, hot upsetting anvil inserts, spot welding electrodes, thread guide inserts, nozzle diaphragm guide vanes, gage anvils and blocks, bushings, high-temperature pressure vessels, and hot spinning tools.

Elevated temperature test machines use cermets in compression heads, tensile test heads, anvils, and for balls in hot hardness testers.

The cermet is considered an intermediate step between metals and nonmetals; it includes all composites of any inorganic compound intimately bonded mechanically or chemically with a metallic constituent. The resultant properties usually differ from those of the parent constituents. Though the new combina-

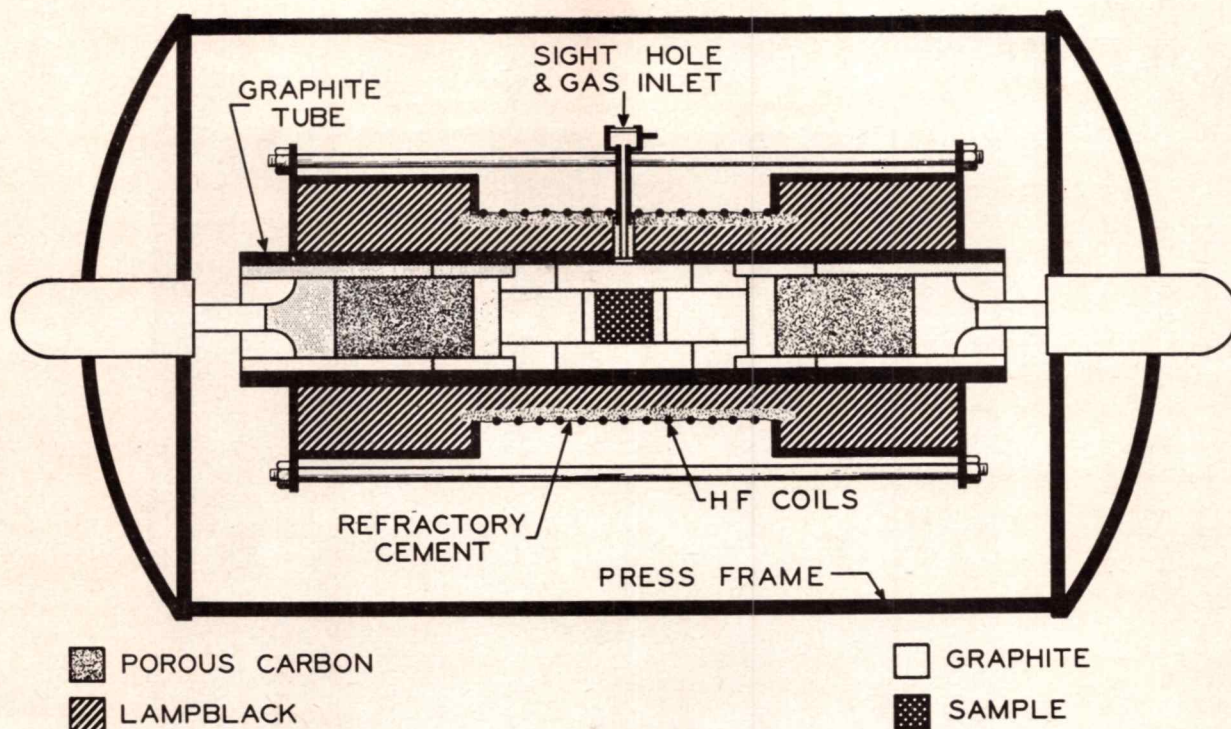


Fig. 3—Fifty-ton horizontal hot press assembly.

tions are hard and refractory, the physical data are incomplete.

● ● Classifications of Cermets

A significant classification of cermets relates to the type of union encountered. On this basis, there are three types.

1. *Mechanical mixtures* are characterized by a sharp interface between adjacent particles, that is, a sharp line of demarcation exists where no reaction has occurred between grains at the boundaries. Bonding prevails because of a continuous phase that surrounds each grain to form the grain boundary. Some examples of this type of cermet are nickel-beryllium oxide and molybdenum-thorium oxide.

2. *Interfacial metal-ceramics* are characterized by a boundary that forms as a result of reaction between the grains and the additive that has been included to make up the cementing medium at the grain boundary. These cermets are processed at temperatures far above the range of application to achieve the reaction. Examples of this type of cermet are chromium-aluminum oxide and silicon-magnesium oxide.

3. *Solution cermets* are formed from an assembly of grains where either the grain or the additive at the grain boundary serves as a solvent and dissolves a portion of the other component. Examples of this category are zirconium-aluminum oxide, beryllium-magnesium oxide and silicon-thorium oxide.

Four conditions must be met for selection of high-melting and oxidation-resistant cermets:

1. Bonding must occur between metal and nonmetal.

2. The metal's melting point must be above the operating temperature.

3. The metal's oxides should be refractory in relation to the operating temperature.

4. The lattices of the oxides that form must be sufficiently tight to decrease diffusion of oxygen inward, or metal ions outward.

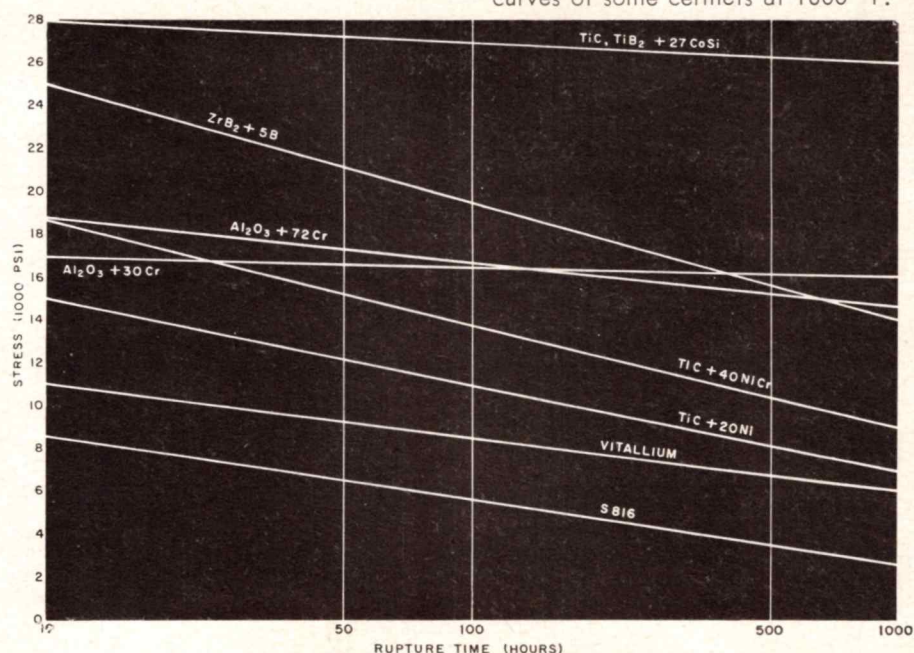
The first three conditions are self-evident, but the last one warrants further treatment. In order for oxidation resistance to exist, the lattice openings of the crystal structure should be smaller than the oxygen ion which always has a tendency to diffuse inward from the surfaces. The size of these lattice openings is determined by the radii of the metallic ions around which nonmetallic ions pack. Therefore, combinations of metallic and nonmetallic ions are selected, whose probability for forming tight oxide compounds at elevated temperatures is high.

● ● Methods of Fabrication

Cermets may be fabricated by conventional methods used in ceramics and powder metallurgy. One of these methods is cold pressing, which requires a conventional press and suitable dies. The cermet mixture is first prepared by mixing the powdered metal with the powdered refractory material in blending or ball-milling equipment until the desired uniformity of distribution of both components is achieved. Mixing by ball-milling techniques tends to smear the metal over the ceramic particles, resulting in a more uniform mixture. The use of balls made of the metal to be employed in the metal-ceramic

CERMETS

Fig. 4—Tensile stress rupture curves of some cermets at 1800° F.



serves the same purpose, but the amount of metal thereby introduced cannot be easily controlled. The particle size and shape of the powders are important for good compaction and for the later sintering operations; a range of grain sizes from coarse (150 microns) to fine (—44 microns) is generally required. The finer the particle size fractions, the greater is the effective surface area of the powders. With larger surface areas, more intimate mixing is possible and better wetting or bonding between metal and non-metal results. However, there is a practical limit to the reduction of grain size and to the increase of surface area beyond which there are diminishing returns. One disadvantage of using extremely fine metallic powders is that they tend to oxidize rapidly; even iron and nickel, 0.1 micron and finer in size, can be highly pyrophoric. Further, with increased surface area and increased amounts of adsorbed air or gas films, some powders have greatly diminished packing densities and become more difficult to handle. Consequently it is preferable to compromise and achieve uniformity of composition with dense packing by taking advantage of the laws of particle packing. If three ranges of sizes are used, namely, coarse, medium, and fine, a densification up to 70 percent may be expected by cold pressing.

The shapes produced by this method are necessarily simple, as complicated shapes are not easily removed from the dies, and usually do not possess a uniform density. Additional densification usually occurs during the subsequent sintering or firing operation, depending on the metal-ceramic composition. Firing is accomplished in the conventional manner with an inert or controlled atmosphere to prevent undue deterioration of the metal component. Furthermore, the sintering temperature should not

melt out or boil out the metal. As the porosity of the pressed compact decreases during firing because of shrinkage, coalescence, wetting, and recrystallization, the surface area of the metallic particles subject to oxidation is appreciably reduced. A fired metal-ceramic compact is consequently more stable than the unfired mixture.

Briquetting or cold compacting of metal-ceramic powder mixtures can be advantageously performed in certain cases with the use of rubber dies. Contouring of the rubber molds imparts fairly intricate shapes to the compacts. Steel dies or retainers are employed to support the rubber die parts. Pressures up to 20 tons per square inch are frequently used and may be exerted by a ram which works directly against the rubber. Isostatic application of pressure makes possible the production of bodies of relatively uniform density.

Table I
COMPARATIVE PROPERTIES OF COMMERCIALY AVAILABLE CERMETS

	Al ₂ O ₃ +Cr	TiC+Ni	WC+Co	Cr ₃ C ₂ +Ni	ZrB ₂ +Ni
Hardness, Ra	68	83-93	85-93	88	90
Transverse Rupture Strength (1000 psi)	50	125-250	200-385	100	66
Compressive Strength (1000 psi)	—	550	520-800	—	—
Density, (lbs/ft ³)	375	340-405	745-940	435	330
Coefficient of Thermal Expansion to 1200°F (10 ⁻⁶ /F°)	4.7	4.5-5.8	2.5-4.0	6.0	2.7
Thermal Conductivity (BTU-in/hr ft ² F°)	64	232	197-602	—	191

HYDROSTATIC PRESSING. The hydrostatic die lends itself to cermet powder pressing. This method applies hydraulically a more uniform pressure than does rubber pressing. Fig. 2 shows a type of high-pressure, hydrostatic pressing chamber which is used at pressures up to 50 tons per square inch for molding powdered materials. This cross-sectional view illustrates a high-alloy steel die block with a mild steel casing, lightly shrunk or press-fitted on for safety reasons. The die is securely held against a hydraulic press platen at the base; the die punch is rigidly fastened to the upper press platen. In the enclosed cavity is the specimen to be consolidated, completely enveloped in a rubber bag to prevent contamination by oil. Oil or a water-soluble oil-water mixture hydraulically transmits any pressure applied by the punch. As pressure is increased, the powder compact is uniformly consolidated. After the composition has been pressed, the punch is withdrawn and the rubber bag is removed with the specimen. By this method of homogeneous compaction, it is often possible to make usable parts from pure abrasive powders which, if fabricated by the usual cold-pressing techniques, would require binders to ensure adequate green strength for handling. Binders added under such circumstances increase the porosity of the bodies. Hydrostatic pressing offers the added advantage of producing bodies that are free of laminations and planes of weakness, and that have a uniform density regardless of shape of compact. Large blanks may be hydrostatically pressed, and subsequently machined and fired to high density. The uniform shrinkage characteristics of hydrostatically pressed bodies is of great significance and value in the production of homogeneous, unstrained bodies.

In general, hydrostatic pressing may be employed to produce bodies of metal-ceramic mixtures of adequate strength at consolidation pressures of 5 to 20 tons per square inch. However, for beryllium carbide-metal composites, it has been empirically proved that better physical properties are obtained with forming pressures of 60 tons per square inch.

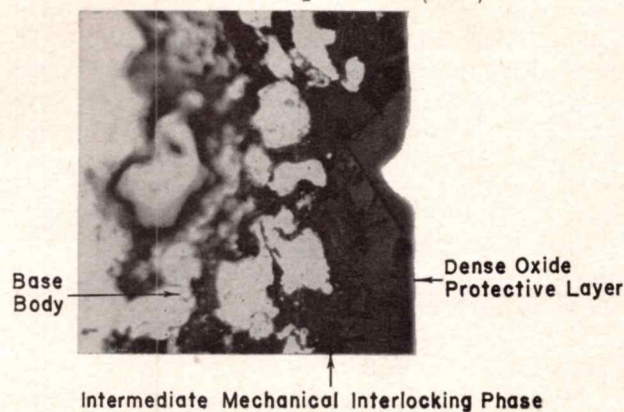
HOT PRESSING. Cermets may also be produced by

hot pressing. For the hot pressing operation, the mixture of metal and ceramic powders is packed into graphite dies and compressed with graphite punches at temperatures determined by the amount and nature of bond metal and ceramic. The molding pressure is maintained between 2000-5000 psi. The travel of the punches into the die cavity, as compaction progresses, indicates whether or not the hot pressing operation is developing satisfactorily; under correct molding conditions, the powders tend to occupy the volume calculated for a particular composition at maximum (or theoretical) density in the die. If the die breaks, or if leakage occurs past the punches, the molding temperature and the pressure or both are too low. Under ideal conditions, the punch travel terminates at a point corresponding with the pre-calculated incompressible volume of the compact at approximately theoretical density.

Hot pressing offers these advantages: shorter time to fabricate bodies; very fine powders can be used without the occurrence of cracking; and high densities may be obtained at lower temperatures.

Fig. 3 shows a cross-sectional view of a furnace and press arrangement. The die is supported by a 10" O.D. graphite tube that extends over the length of the furnace. This tube is inductively heated by high frequency coils. The die volume is supplied with a

Fig. 5—Oxidation protective film on $MnB_2 + Si$. (250x)



protective atmosphere from a sight hole and gas inlet combination. A small oil pump maintains pressure at any desired value within the range of the press.

When certain metal-ceramic compositions require the use of a protective, essentially non-carbonaceous atmosphere during the hot pressing operation, hydrogen, argon, nitrogen, or helium are introduced into the die chamber. A non-carbonaceous environment is desired particularly when such metals as titanium, chromium, or molybdenum are added as the metallic component. In these cases, die liners of molybdenum, tantalum, or tungsten have been used successfully. For metal-ceramic compositions involving hot pressing at temperatures less than 3090°F, the lampblack or silicon carbide insulation may be replaced by ZrO_2 or MgO . At these lower temperatures, graphite die parts still find general use because of the ease of machining and low cost of the material.

Table 2
TRANSVERSE STRENGTHS OF CERMETS
(psi)

Composition	75°F	1800°F
95 WC + 5 Co	200,000	—
80 TiC + 20 Co	150,000	100,000
95 NiAl + 5 Ni	129,000	69,000
85 CrB + 15 Ni	120,000	—
28 Al_2O_3 + 72 Cr	80,000	57,000
96 ZrB_2 + 4 B	70,000	62,000
73 TiC, TiB_2 + 27 CoSi	65,000	87,000
70 Al_2O_3 + 30 Cr	53,500	33,000
78 Cr_3Ti + 22 Ti(O,N)	50,000	100,000
50 Cr_3Si + 50 Cr	49,000	130,000
60 SiB_2 + 40 Co	45,000	—
75 MnB_2 + 25 Si	40,000	19,000
87 B_4C + 13 Fe	39,000	31,000
65 Be_2C + 35 Be	35,000	—
72 BeO + 28 Be	35,000	—

CERMETS

Slip casting methods are also used to prepare cermet bodies. Some noteworthy observations about the casting of chromium-alumina combinations are that the slips should contain approximately 70 to 75 percent solids and 30 to 25 percent water with 1.0 to 1.5 percent deflocculant. Deflocculants that have proved successful in this type of work are Daxad 11 and 23 and ferric chloride.

Extrusion methods also lend themselves to cermet fabrication. Such plasticizers or lubricants as polyacrylates and alginates must be used in larger quantities than are required in cold pressing techniques.

• • Physical Properties

There are little data about the mechanical and physical properties of cermet compositions. However, now that the search for new combinations shows considerable promise and fabrication techniques have been developed, more design data are becoming available. The requirements that must be met by cermets vary with the intended use, within large limits. One of the most important practical requirements is reduction in brittleness, since ceramic materials exhibit acceptable high-temperature strengths, but fail too frequently when rapid heating or mechanical impact is applied. Some confusion exists concerning the impact strengths of cermets in comparison with cast high-temperature alloys. Much of the impact testing of cermets has been done on testers for plastics, which give values in inch-pounds. It is customary to use a small specimen with dimensions $3/16'' \times 3/10'' \times 1\frac{1}{2}''$, which is broken on a $1\frac{1}{4}''$ span. Under these test conditions, cermets show values in excess of 20 inch-pounds, well within the range of some cast high-temperature alloys. Metals are generally tested on impact machines of higher capacity that give values in foot-pounds and use a specimen $0.394'' \times 0.394'' \times 2.165''$. Charpy test results for cermets show good impact resistance at 5.0 foot-pounds.

Oxidation resistance also is an important parameter that must be considered because metals corrode extremely rapidly at elevated temperatures with oxidizing environments. Oxidation resistance of a cermet

can be adjusted to the application. Those composites having the best oxidation resistance form a tenacious and impervious oxide coating in a short time. Fig. 4 is a photomicrograph of a hot pressed $MnB_2 + Si$ body after a 48-hour oxidation test at $2010^\circ F$. The photograph, taken at the interface of the oxide layer and body, shows the type of dense and tenacious coating necessary to prevent oxidation.

Table 1 is a resume of some of the latest information on a few commercially available cermets. The low densities of most cermets, as compared to tungsten carbide composites and superalloys, are immediately apparent. In rotating parts the centrifugal stresses are much lower than those developed in superalloys. The cermets retain more of their strength at elevated temperatures than do most of the alloys; this characteristic helps in overcoming the centrifugal stresses. Hardnesses are high; consequently, wear resistances are good. Young's modulus values are greater than those of superalloys. Electrical resistances are intermediate between resistors (ceramics) and conductors (metals) and usually increase with temperature. Thermal conductivities are higher than those of superalloys, while thermal expansions are low, permitting good thermal shock resistance.

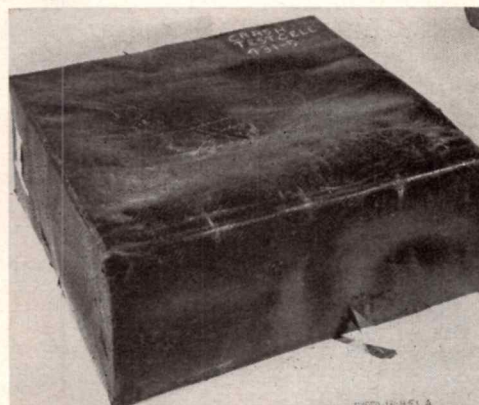
A significant method for relating the variables of temperature, tensile stress, and time of failure is the stress rupture test. Fig. 4 is a graphical comparison of the stress rupture properties of several cermet composites and two well known high temperature alloys. It is obvious that several composites appear promising for many high temperature applications. The stress rupture values reported for the materials are as high as, or higher than, the best values reported for superalloys. Because of the lower specific gravities of cermets, superior performance can be predicted in applications involving rotating parts.

Table 2 presents transverse rupture values of a large number of cermets that have been or are being investigated. The values at elevated temperatures give an indication of the resistance of the composites to oxidation. The reason some cermets show an increase in the transverse strength with rise in temperature is because recovery occurs beyond the yield point in the same fashion that it exists in metals. Therefore, the ultimate load increases with hot deformation to a new value for failure at elevated temperatures. END

CERMETS	
Advantages	Disadvantages
1. Greater thermal shock resistance than ceramics. 2. Good wear resistance. 3. Excellent mechanical properties at elevated temperature. 4. Generally use nonstrategic materials as high-temperature substitutes of critical metals. 5. High strength-to-weight ratio.	1. Less thermal shock resistance than metals. 2. Less ductility at all temperatures. 3. High cost of fabrication.



Test structure just prior to its impact against sandbags. The structure, which is a built-up wing section, contains crash resistant fuel cell, is traveling about 70 mph, impacts for 0.05 second, experiences peak loading between 150 and 200, experiences an average g-loading of about one-third its peak loading.



Typical crash resistant multiple-ply fuel cell.

CRASH RESISTANT FUEL TANKS Are on the Market

By WILLIAM BELLER

**New tanks pay slight weight penalty.
CAA asks industry to design crash-resistant fittings.**

IN THEIR DESIGNS of new commercial aircraft, engineers can now specify "crash resistant" fuel cells. These are bladder-type cells made of layers of rubberized nylon cloth.

The required unit-area weight of a cell depends on amount of crash resistance desired. Roughly, for a two-engine transport, a bladder cloth weighing 0.4 lbs/ft² would be used. Such cloth would make the fuel cell about 175 pounds heavier than the conventional bladder cell.

This weight penalty is expected to disappear with improvements in design; for example, it is not required that the cell be of constant thickness—the top could safely be made thinner than the other surfaces.

The Technical Development and Evaluation Center of the Civil Aeronautics Administration, Indianapolis, Indiana, led this study. Goodyear Tire and Rubber Company, and United States Rubber Company fabricated and furnished the cells.

For purposes of crash resistant tank design, CAA has defined a satisfactory wing fuel tank as one that is "able to contain fuel under any imposed load up to a maximum of that necessary to tear the wing from the fuselage."

From this definition it follows that lighter fuel cells would be specified for outboard wing stations where a relatively light chordwise load would fail the wing at its root; whereas, heavier fuel cells would be needed at inboard stations where the load's moment arm is shorter.

Charles Bennett, CAA project engineer, announced on December 15 that test data are nearly complete

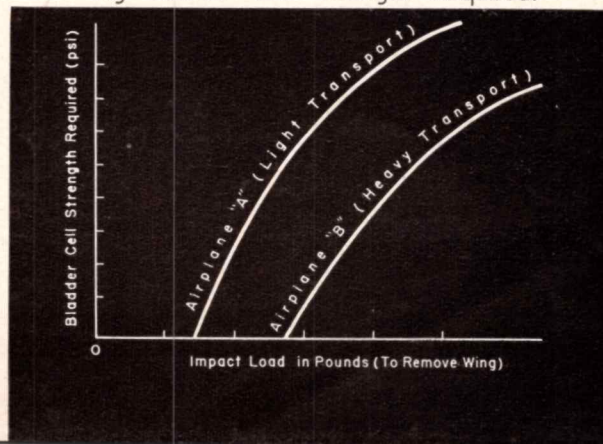
that would permit a designer to enter a series of curves with *Impact Load* and leave with *Bladder Cell Strength Required*. Fig. 1 shows the probable shape and coordinates of these curves. For planes not fitting the descriptions of Plane A or Plane B, it may be necessary to interpolate or extrapolate to find a bladder strength. Note that because the wing structure itself can absorb light impact loads, the curves do not pass through the origin.

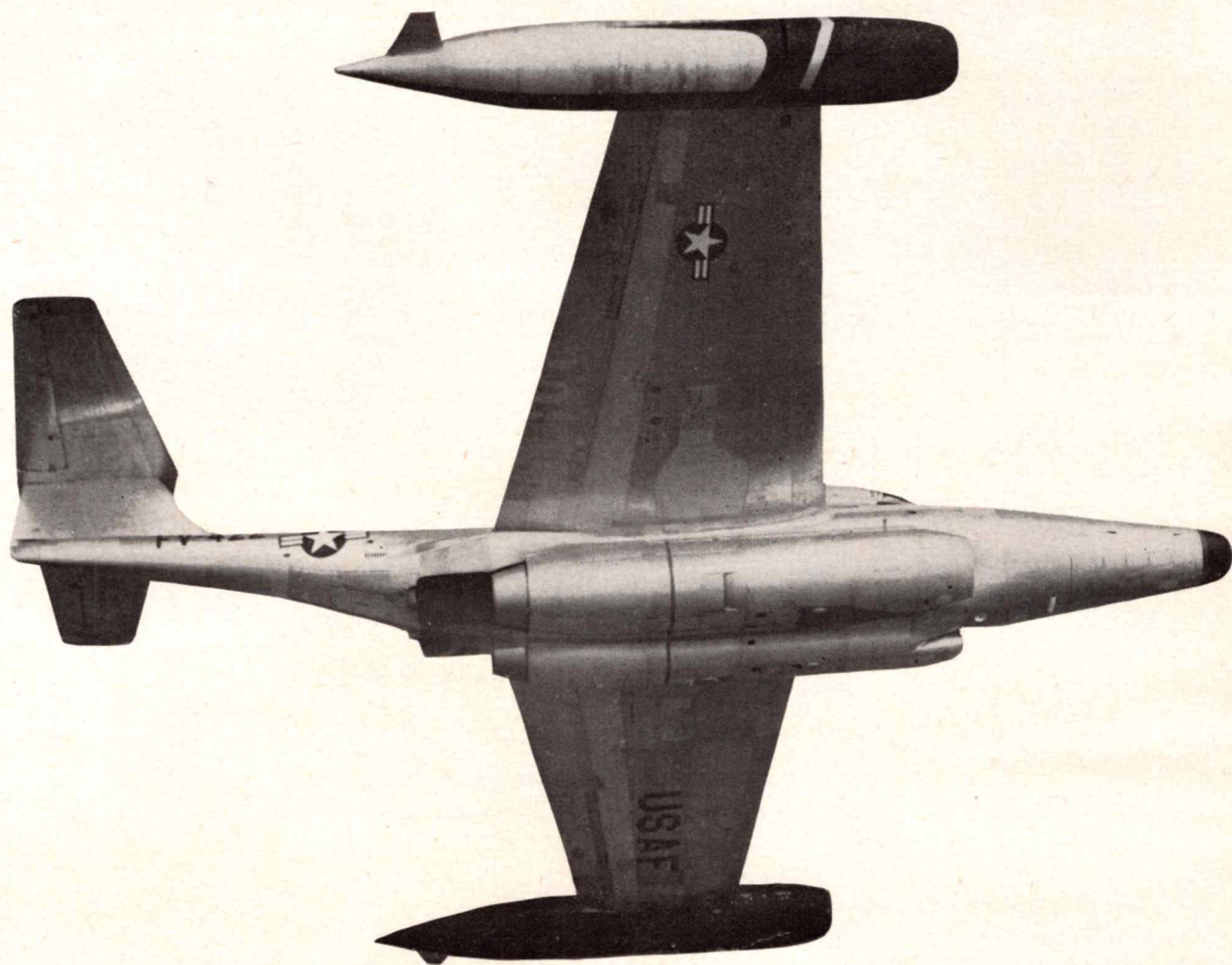
In June 1955, CAA starts on the second phase of its fuel tank program: the development of fittings that will not jeopardize the crash resistant characteristics of its new bladder cells. The program calls for quick-disconnect self-sealing types of fuel line couplings, filler openings, hanger fittings and sump arrangements.

The Technical Center of CAA invites suggestions and cooperation of industry in this work.

The ideal crash resistant fuel tank is one that, if a plane crashes, would be found with its surface whole, its fittings sealed, and it gas contained. END

Fig. 1—Probable shapes of curves giving Bladder Cell Strength Required.





DESIGN OF THE *Scorpion*

NORTHROP'S F-89D features:

decelerons;

thermal anti-icing system;

fully powered control system;

rockets in wing tip pods.

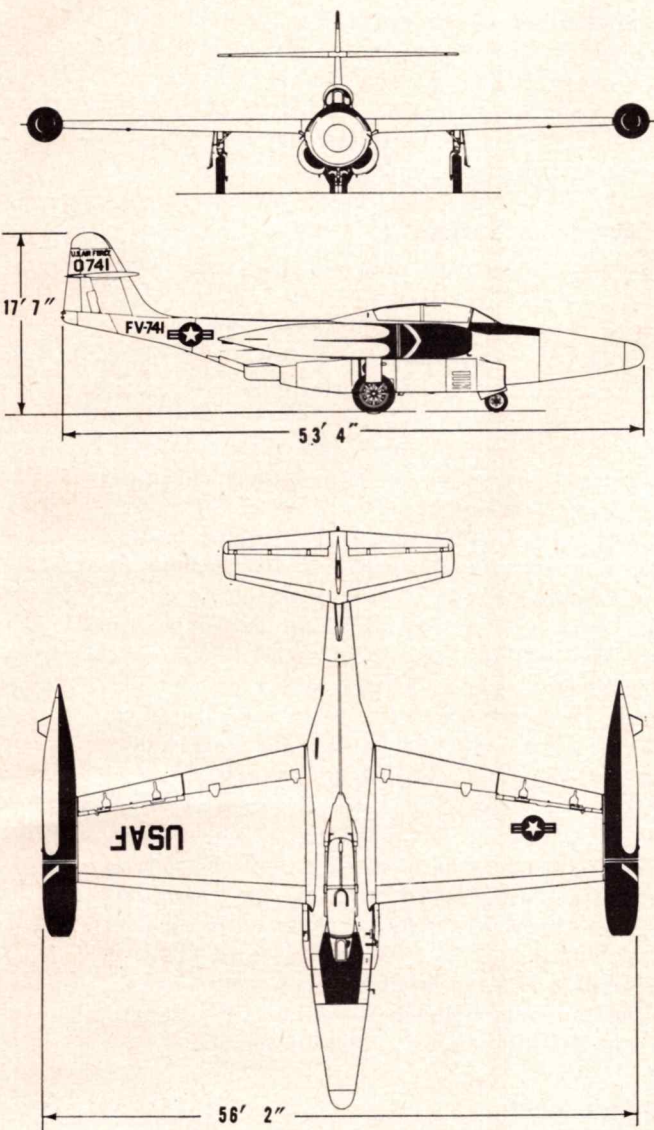
THE NORTHROP SCORPION F-89D arose out of the combined efforts of the United States Air Force and Northrop Aircraft, who wanted an aircraft for continental defense.

Outstanding characteristics of the Scorpion are its fully powered control system, aerial speed brakes, thermal anti-icing system, rocket armament, and powerful afterburner-equipped Allison J-35 turbojet engines.

● ● General Description

The Scorpion is a high-altitude, midwing, twin-engined, jet-propelled, all weather interceptor manned by a crew of two, pilot and radar observer. They sit tandem on ejection seats in a pressurized cockpit enclosed by a single jettisonable canopy.

The plane's characteristic *Scorpion* silhouette is created by its upswept tail assembly. The horizontal stabilizer, located halfway up the vertical stabilizer,



Three-view of F-89D

is above the hot gases emitted from the twin jet exhausts. This position diminishes the effects of turbulence and downwash.

Exact performance is being withheld by the Air Force because of military security. However, it has been announced that the plane is capable of operating at speeds in the 600-mph-class, and at altitudes higher than 45,000 feet.

The F-89D is an unusually large fighter-interceptor plane. Its dimensions are: wing span, 56'2"; fuselage length, 53'4"; height, 17'7". Weight: more than 40,000 pounds.

● ● Fully Powered Control System

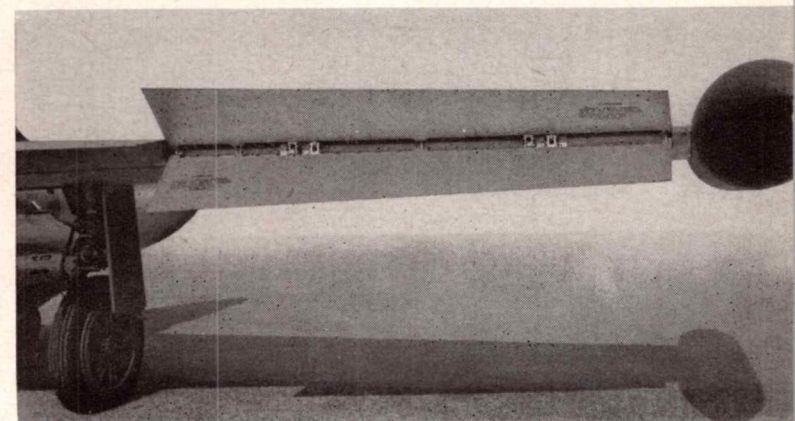
All flight controls in the F-89D are hydraulically powered. This system features irreversibility of control, an extreme advantage in high Mach airplanes where compressibility shock waves impose erratic loads over control surfaces.

To assist the pilot controlling the plane, the designers built "feel" into the stick and rudder pedal mechanisms by simply attaching appropriate springs to them. For the elevator, additional help is provided by a force-feel system consisting of a force bellows and bob weight combination, which produces "feel" in direct proportion to air speed and load factor. The force bellows is linked to the control stick mechanism so that movement of the stick opposes ram air pressure within the bellows. Thus an increase in air speed results in an increase in resistance to stick movement. When a positive load factor is applied to the airplane, the bob weight tends to move the stick forward and to oppose further application. Similarly, when a negative load factor is applied, the bob weight tends to move the stick aft.

The designers provided an emergency flight control system, tied in with the fully powered control system, which enables the pilot to operate the controls without use of engine power.

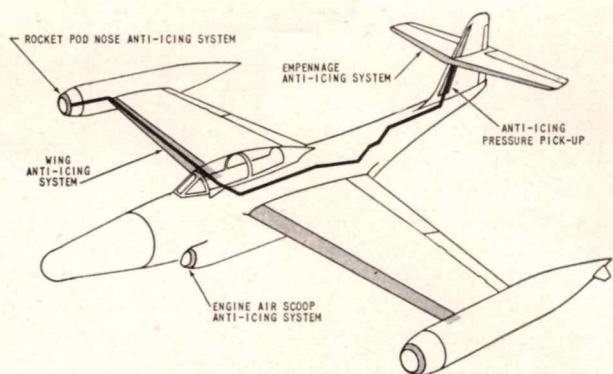
No trim tabs are used in the F-89-D. Trim is ac-

complished by moving entire surfaces, thereby offering more positive trim control.

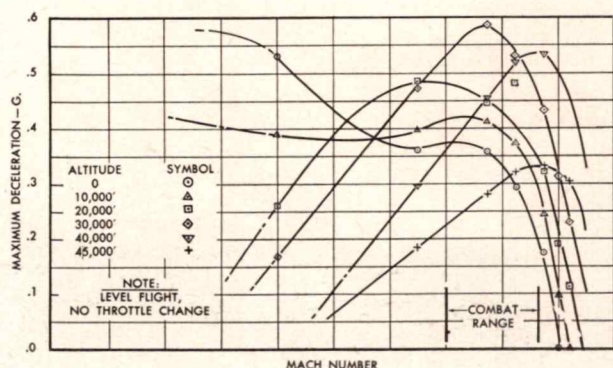


● ● Decelerons

The decelerons on the F-89D are jawlike control surfaces at the outer end of the wing trailing edge, which perform double duties as ailerons and fighter brakes. They enable the pilot to reduce flight speed rapidly and still retain full control of the ship. In normal flight, the jaws are closed and the decelerons function as ordinary ailerons. In dives, they are opened for braking effect. This split-aileron speed brake makes possible a much larger drag surface than other types, and use of the brake has no adverse effect on aileron control. In fact, under some conditions a slight amount of speed brake opening increases aileron effectiveness. Also, since the speed brakes are symmetrical and since they are located almost in line with the airplane center of gravity, their use has negligible effect on trim. They give ex-



The F-89D thermal anti-icing system ducts hot air from engines to various surfaces to prevent or remove ice formations. The anti-icing system embraces windshield, wing, empennage, wing tip rocket pods, engine air intake ducts, and engine forward frame compartments located in engine air intake ducts. Northrop engineers point out that the system does not disturb lines of the airplane by external impediments such as boots or blankets attached to leading edges.



Aerodynamic curves of Scorpion's deceleron effectiveness indicate maximum braking at combat Mach numbers and 30,000 feet altitude.

cellent air speed control without changes in power setting. They permit a high rate of closure in combat while leaving maximum power available for a fast

getaway. This airspeed control also permits faster acceleration in case a go-around is necessary because of an aborted landing. These unique dive brakes are useful in reducing ground roll distances, in dive recovery, in formation flying, in fast letdown from altitude, and in minimum radius turns.

● ● Anti-Icing System

High temperature and pressure air is bled from the engines and ducted to the various surfaces where it is used to heat the outer skin. This thermal anti-icing system prevents formation of ice on the wing and empennage leading edges, wing tip rocket pods, and engine air scoops.

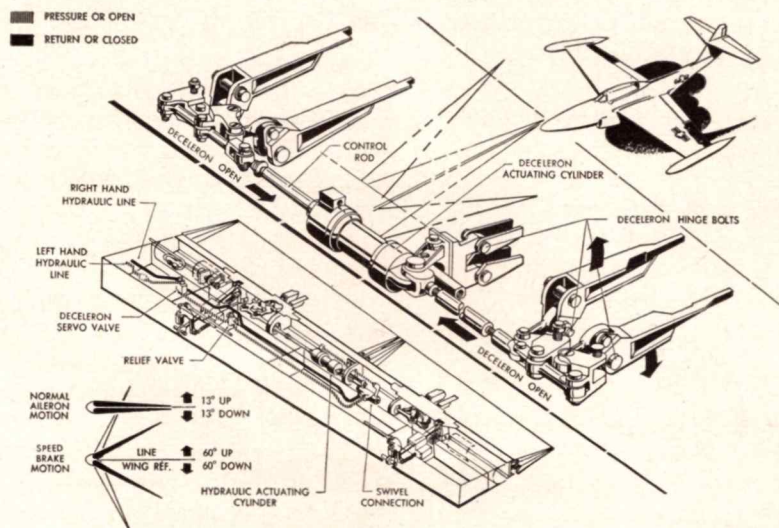
Anti-icing of the windshield, fuel vents and other components is effected by electrical resistance heating. The windshield is unique: it is made of bulletproof glass with a transparent, electrical resistance heating element on each side of the glass to give de-icing on the outer surface and defrosting or defogging on the interior surface. In normal flight, the defogging and de-icing elements are heated continuously.

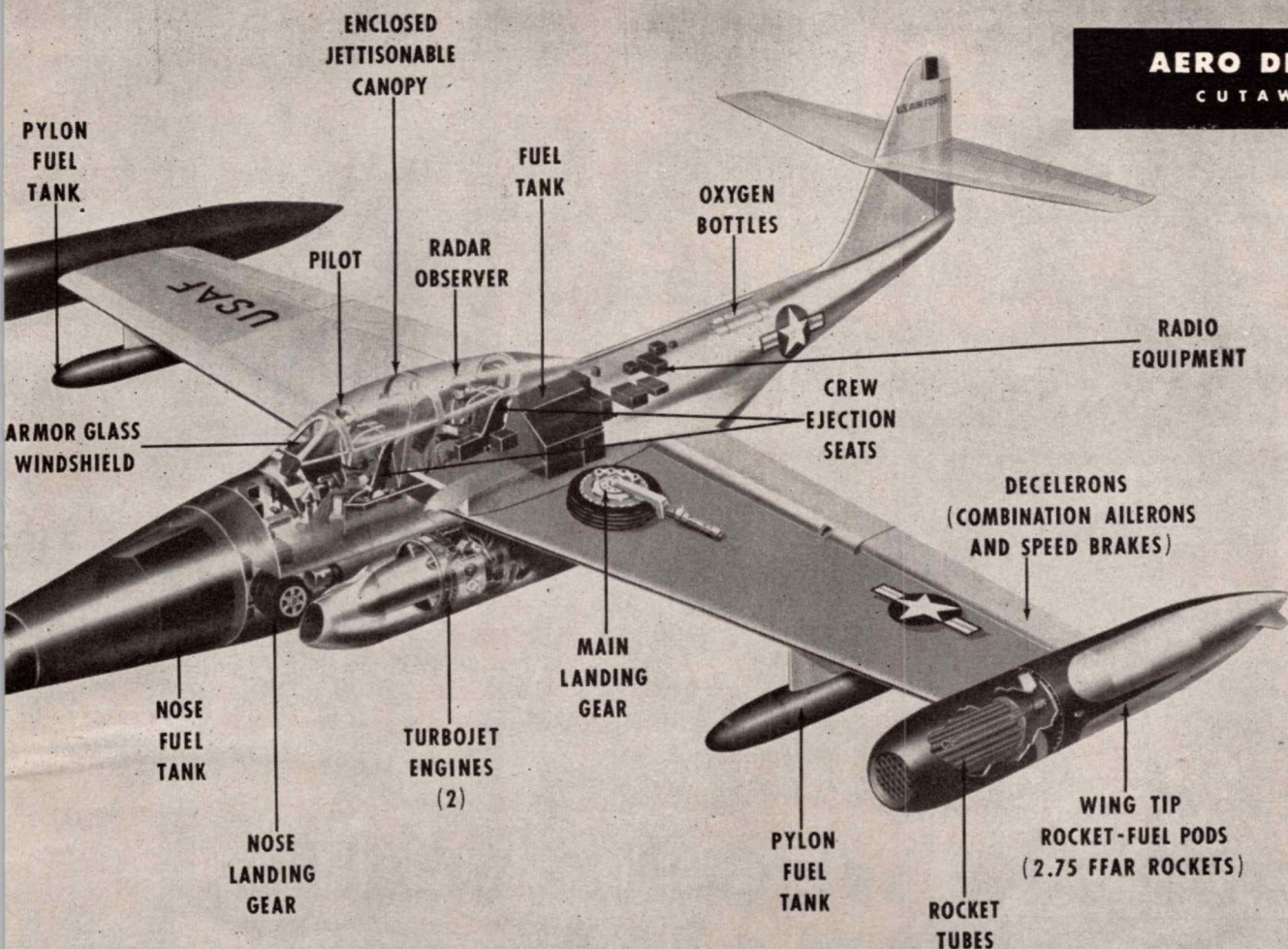
Icing detector probes located in the engine inlet airstream sense the presence of an icing condition. In case of danger, the pilot is warned by a red light on his anti-icing control panel to energize the anti-icing system. He can select either the TAKE-OFF or FLIGHT position of the anti-icing selector switch. In TAKE-OFF position, the wing and empennage leading edges, wing tip rocket pods, and engine air scoops are not heated; thus maximum thrust is kept available for take-off and landing. During flight, if a pilot wishes to know whether icing conditions still exist, he turns the selector switch to OFF thereby enabling the icing detector system to operate.

● ● Armament

The F-89D is armed with 104 2.75-inch folding fin air-to-air rockets, each capable of downing the largest bomber with a single hit. The rockets are carried in large wing tip pods. Kill probabilities are high in combat since the target area blanketed when all roc-

Actuating linkages and hydraulic lines of Scorpion's decelerons shown in design details.





kets are fired is extensive. Use of the wing tip pods provides improved dispersal of rockets, since two sources of firepower are used instead of a single concentrated source.

Placement of the rockets in wing tip pods instead of in conventional fuselage or under-wing locations provides additional combat advantages. Not only can large numbers of rockets be carried in the wing tip pods, but firing of rockets does not interfere with vision of the crew at the critical moment of interception. Importantly, engine air intakes are not exposed to smoke and debris produced by rocket firing.

The rockets can be fired in a single, giant volley, or can be fired in groups. This situation enables the Scorpion to make as many as three passes at a single target, or move in for the kill on three separate enemy aircraft.

The 104 rockets, 52 in each wing tip pod, replace the six 20-mm nose-mounted cannon of earlier F-89 models.

● ● Auxiliary Tanks

Auxiliary pylon fuel tanks can be mounted beneath the wings, approximately midway between the fuselage and wing tip rocket pods. Although the tanks are nearly 15 feet long and together weigh more than

two tons when filled with fuel, Northrop engineers say they do not appreciably affect the high speed of the airplane. The fuel tanks can be ejected by use of an explosive cartridge fired by the pilot.

● ● Squadron Assignments

A striking fact about F-89D assignments is that these aircraft have consistently been assigned to the northern perimeter of defense where all-weather operation is required and where, if attack comes, the enemy is apt to make his first appearance.

The all-weather characteristics of the rocket-armed *D* model were verified by the cannon-armed F-89C's. All-weather ability of the earlier Scorpions was proved in climatic tests at Eglin Air Force Base, and emphasized by the recent assignment of the 74th Fighter-Interceptor Squadron equipped with F-89C aircraft to Thule Air Base, the northernmost U. S. air base. Significantly, the 74th squadron moved its planes from Presque Island, Maine to Thule with military precision; the squadron was declared operational and on alert within a few hours after the first Scorpion touched down on the Thule runway.

Today, Scorpion aircraft are operational in three commands: Air Defense Command, Alaskan Air Command, and Northeast Air Command. **END**

Engineers can determine C.G. travel of an experimental plane or missile while it is on the ground rather than having to rely on estimates or having to wait for flight results.

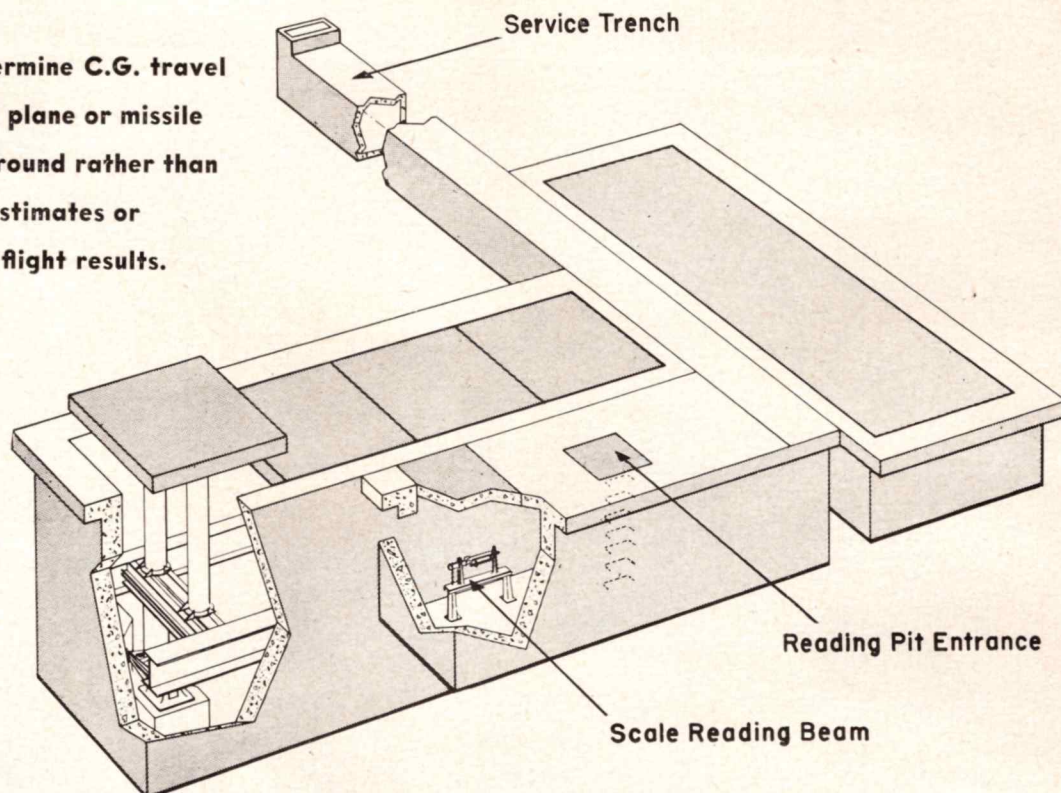


Diagram of pits that house the plane weighing scales. One of the four floating nose platforms is shown extended.

PLANE WEIGHING SCALES YIELD C. G. DATA

A WEIGHING SYSTEM installed in Chance Vought Aircraft's missile hangar can weigh a 90,000-pound airplane, and can give the data necessary for plotting shifts in a plane's center of gravity. Plane weighing scales have been in use for some time, but the present installation is believed to be one of the first used for C. G. studies.

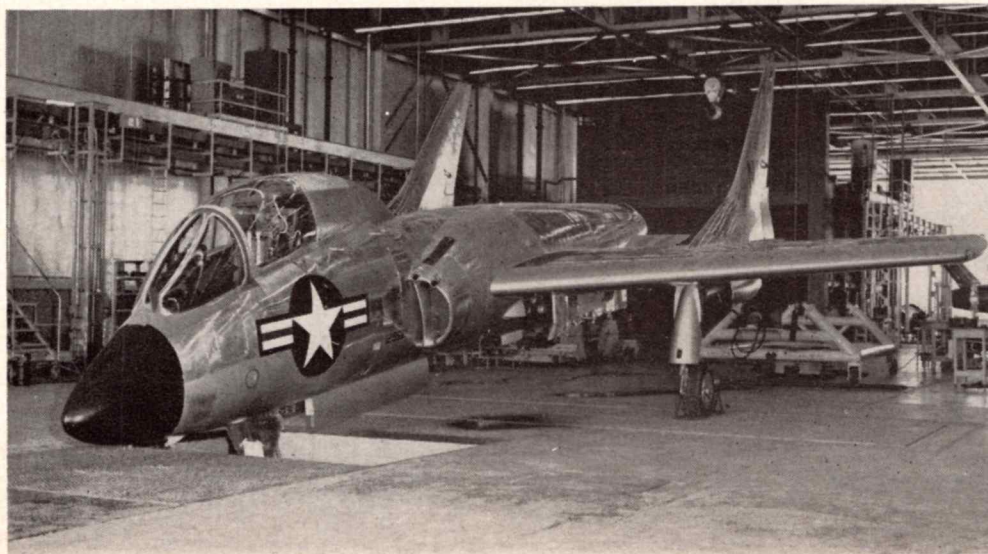
The scales can weigh aircraft from 10 pounds to 90,000 pounds that have wheelbases in the range between

6 feet and 50 feet. Hydraulic elevators change the aircraft's nose level to simulate dive, climb, or level flight. Results are accurate to within 0.1 percent. The weighing job, which formerly took one hour, now takes 15 minutes.

The weighing platform is built in the form of a "T". Two 30-ton motor truck scales do the weighing. The two main landing gear wheels of the aircraft stand on the crossbar of the "T", which is a floating concrete

slab 10 feet by 34 feet. Below this slab is a five-foot pit which houses one of the scales.

The nose wheel of the plane or missile rests on the vertical part of the "T". This segment is divided into four sections, each of which can be lowered or raised five feet thereby permitting the attitude of the aircraft to be changed to simulate flight positions. The scale here is located in a pit 20 feet deep, 34 feet long, and 10 feet wide. END



An F7U-3 Cutlass stands on the newly-completed \$75,000 scale sunk in the floor of the Chance Vought Aircraft missile hangar in Dallas, Texas. The scale can be used for weighing aircraft and missiles and for center of gravity shifts corresponding to different fuel loadings and flight attitudes.

When Should Alloy Steels Be Ordered to Hardenability?

This is the fifth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What is hardenability and how does it differ in carbon and alloy steels?

Hardenability can be defined as the capacity of steel to develop a desired degree of hardness, usually measured in depth. It is produced by special heating and cooling. Carbon steel, except in small sections, will normally harden to a depth slightly below its surface, while alloy steel can, under certain conditions, harden uniformly through its entire cross-section.

Surface hardness obtainable after quenching is largely a function of the carbon content of the steel. Depth hardness, on the other hand, is the result of alloying elements and grain size, in addition to the carbon present in the steel.

In general, where hardenability is the prime consideration, it is not too important which alloy steel is used, just as long as there is sufficient carbon present to give the prescribed hardness, and enough alloying elements to quench out the section. We might mention here that it is not considered good practice to alloy a small section excessively, since too free a use of alloying elements adds little to the properties

and can, in some instances, induce susceptibility to quenching cracks.

There are, of course, numerous cases where factors other than hardenability must be considered; such factors as low-temperature impact, heavy shock, creep-resistance, and the ability to resist temper brittleness. Through-hardening, therefore, is not always desirable. For example, shallow hardening is often necessary in shock applications, because a moderately soft core is essential.

Our metallurgists will gladly explain where it is advantageous to order alloy steels to hardenability, and where it is preferable to order by analysis. They will also give you any help you may require in connection with heat-treating and machining problems.

And when in need of steels, remember that Bethlehem manufactures the entire range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades. We can meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM *ALLOY* STEELS





Leadership demands constant achievement

Map shows major routes of these 18 Super Constellation airlines:

(Figures represent total unduplicated route miles for each airline.)

	Air France 162,000
	Air-India International 16,100
	AVIANCA (Colombia) 28,500
	Cubana (Cuba) 8,600
	Deutsche Lufthansa (Germany) 11,200
	Eastern Air Lines 12,700
	Iberia (Spain) 41,000
	KLM (Holland) (144,000)
	LAV (Venezuela) 16,700
	Northwest Orient Airlines 17,300
	Pakistan International 5,200
	QANTAS Empire Airways 68,800
	Seaboard & Western (All-cargo routes applied for)
	TAP (Portugal) 11,300
	Thai Airways (Thailand) 19,700 (proposed)
	Trans-Canada Air Lines 19,000
	TWA-Trans World Airlines 33,000
	VARIG (Brazil) 19,000

Insignia on map show airline headquarters.

Every month another airline starts *Super Constellation Service*

To you this means that soon you can fly more places faster, in greater comfort than ever before . . . on big, fast, luxurious transports that are world-renowned for dependability—Lockheed Super Constellations . . . now with turbo-compound power.

Already more new Super Constellations are being built to airline order than any other comparable air transport . . . ordered by more than twice as many leading world airlines. So many, in fact, that every month during 1954 a different airline started Super Constellation service. This record is continuing in 1955.

More world airlines (18) have ordered the Super Constellation than any comparable transport—worth remembering next time you fly.

Lockheed

AIRCRAFT CORPORATION

BURBANK, CALIFORNIA, AND MARIETTA, GEORGIA

Look to Lockheed for Leadership

YOU CAN FLY MORE PLACES
ON FAMILIAR SUPER
CONSTELLATIONS THAN ON
ANY OTHER LONG-RANGE
TRANSPORT IN THE WORLD

MILLIONS OF HOURS AHEAD!



New hand-size cooling turbine weighs less than 2 pounds!

You've read about the new deadly miniature combat jets like the Douglas A4D. Here, even the rivets had to be scaled down in size to meet the critical weight problem.

Existing cooling components could not meet the exacting specifications. AiResearch engineers, designers of the first midget cooling turbine (right) for America's early jets, solved the

problem by designing the refrigeration turbine shown on the left.

This new turbine weighs less than 2 lbs. It produces 15½ h.p. and has the cooling capacity of 2300 lbs. of ice per hour. *Its weight is half the original unit, yet it has twice the cooling capacity.* Operating on the A4D and the Grumman F9F9, this cooling turbine has already demonstrated its

high efficiency and extremely low oil consumption.

In the field of air turbine refrigeration, AiResearch has devoted over 900,000 research and development hours. Nearly 50,000 units have been produced. Still the search goes on relentlessly for ways to achieve ever more efficient performance from smaller units of less weight.

Qualified scientists, engineers and craftsmen are needed now. Write for information.



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AiResearch Manufacturing Divisions

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Designers and manufacturers of aircraft components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS

CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

PREDICTING FATIGUE FAILURES

IN ALUMINUM ALLOY STRUCTURES

Given: 1) Theoretical stress concentration factor.
2) Loading spectrum.

To Find: Fatigue life.

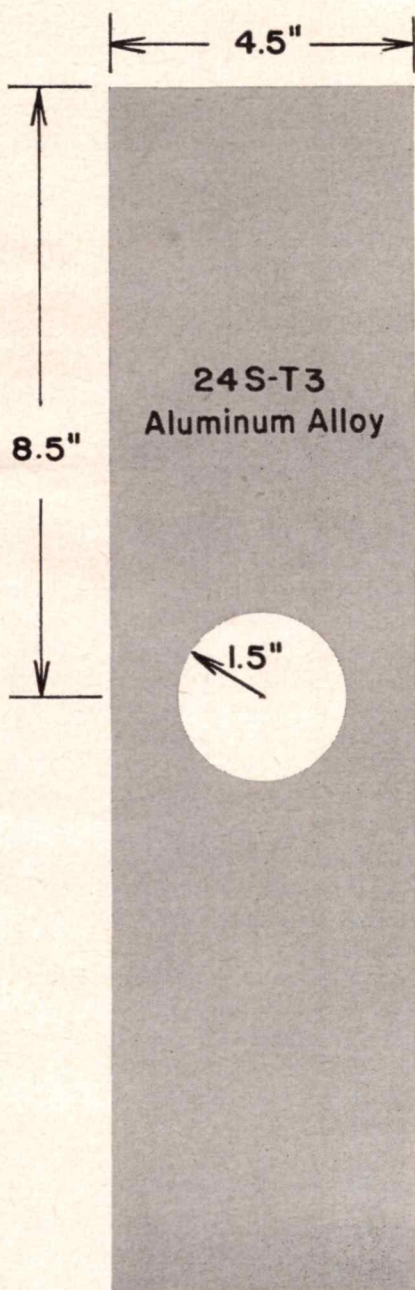


Fig. 1—Notched fatigue test specimen.
(Theoretical stress concentration factor = 2)

By C. R. SMITH
Research Test Engineer
Convair, San Diego

ASSUME that the designer has the design data at hand, including the number of cycles expected of the structure. Usually the number of load cycles is given as a spectrum of loads per flight hour, which spectrum is based on the number and intensities of gusts encountered, flight maneuvers, or both. Loads due to landing or vibration may also have to be considered. In this way, the anticipated service life of the airplane is determined. The problem now resolves itself to prorating the number of loads at each intensity and determining their effective stress amplitudes (Ref. 1).

The term *effective* stress amplitude is used because some of the higher loads cause plastic flow around the points of high concentration, subsequent stress amplitudes of lower levels then being translated downward because of residual compressive stress in the plastically deformed region.

As an example, consider a loaded flat tension

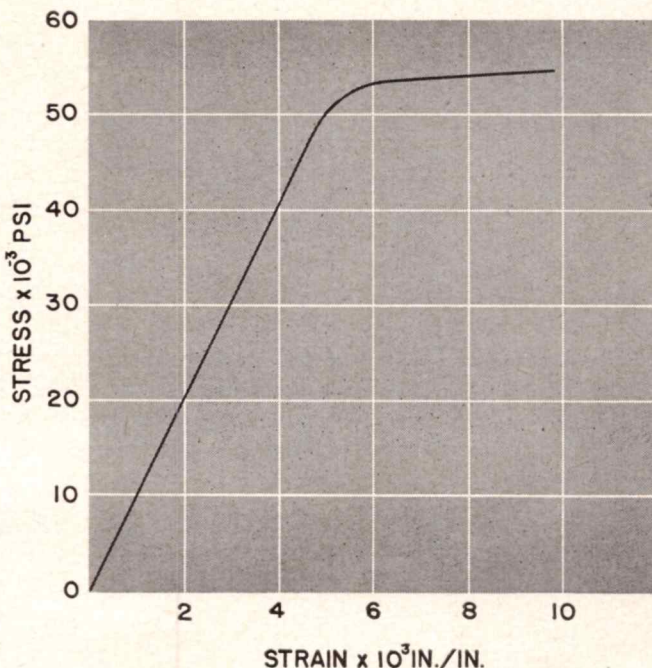


Fig. 2—Stress-strain curve for 24S-T3 aluminum alloy sheet.

coupon having a hole drilled through its center (Fig. 1). Assume that the dimensions indicate a theoretical stress concentration factor of 2. Further, the material, 24S-T3 aluminum alloy, is subjected to repeated loads producing an average net or nominal stress of 40,000 psi. This average stress times the theoretical concentration factor brings the material above its ultimate strength, which is unlikely for the given set of conditions.

Now the stress-strain curve for 24S-T3 (Fig. 2), shows that for 40,000 psi stress there is a strain of 0.0038 in./in. If it is assumed that the strain rate is linear in the plastic range, then one may multiply the strain corresponding to 40,000 psi by the theoretical stress concentration factor, and from the stress-strain curve obtain the peak stress. For this specimen, the strain would be $0.0038'' \times 2$ or .0076"; then from Fig. 2 the peak stress would be 53,000 psi.

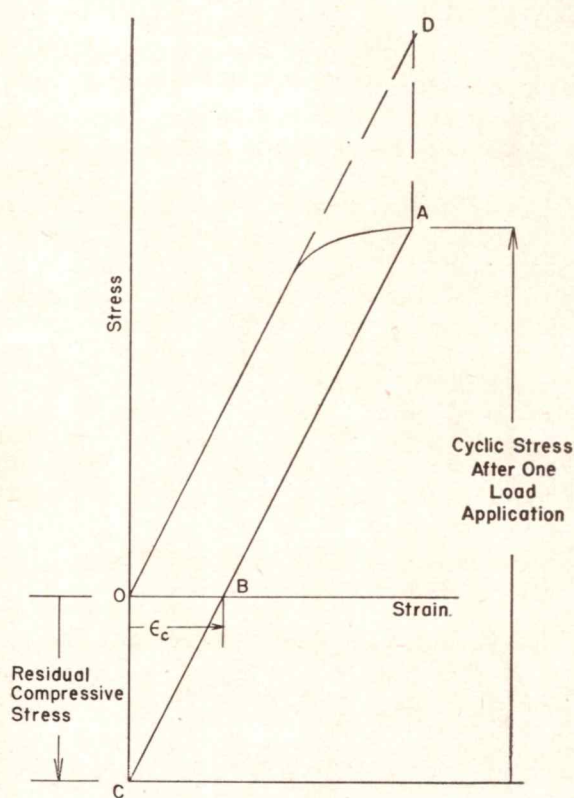


Fig. 3—Stress-strain diagram showing residual compressive stress.

While test data show that for a panel with a large hole (Ref. 2), the strain rate increases after the yield strength has been passed, for material such as 24S-T3, which has a fairly flat curve above the yield strength, some error in strain could be tolerated without appreciably altering the peak stress.

• • Residual Compressive Stress

The next step is to examine the specimen for an unloaded condition. Since the specimen has already experienced plastic flow at the edge of the hole, the affected area is in compression upon relief of load;

this condition is a result of the material which did not experience plastic deformation loading the plastically deformed material. Provided that the amount of area elastically deformed is large compared to that plastically deformed, the return would approach the starting point, or point of zero strain. Assume that this is the case, and that the plastic deformation is retained in the form of residual compressive stress.

A stress-strain diagram is sketched in Fig. 4, where point A represents 53,000 psi, which stress was obtained from the 0.0076 in./in. strain obtained previously. On release of load, the strain follows line AB, the normal pattern of return after plastic deformation. However, when the plastically deformed metal reaches B, the elastically deformed metal has not yet reached a point of zero stress; as it does, it forces the plastically deformed metal to position C: this effect is based on the assumption that the elastic area is very large compared with that area affected plastically. In other words, *the spring constant of the elastically deformed metal is assumed to be infinite compared with that of plastically deformed metal.*

Now the permanent set represented by OB becomes the compressive strain ϵ_c , which in this example corresponds to a residual compressive stress of -27,000 psi represented by the dimension OC, the value being obtained graphically. An analytic method for obtaining the residual stress is accomplished by extending the primary modulus line to point D, which represents the average net stress times the concentration factor. OC is equal to AD; subtract the stress of 53,000 psi at point A from the stress of (40,000 psi $\times$ 2) at point D to obtain the -27,000 psi residual compressive stress at point C.

Fig. 4 shows S-N curves (Ref. 4) for 24S-T3, that is, it indicates the relationship between peak cyclic stresses and the number of cycles to failure. R represents the stress ratio as the minimum stress divided by the maximum stress; as an example, for repeated load the minimum stress is zero, hence $R = 0$; for reversed loads the minimum stress is equal to the maximum stress but is of opposite sign, hence $R = -1$. In the present example, $R = -27,000/53,000$ or -0.5. For a stress ratio of -0.5 and a maximum stress of 53,000 psi, from Fig. 4 the expected life is 9000 cycles. Note that the value of R that considers residual stress differs from the R that is based on nominal net stress; in the latter case for this example $R = 0$.

Similarly, the life expectancy of the part for other stress levels can be found. Fig. 5 shows calculated life values along with test data for comparison (Ref. 5). Ordinates of the curves are in terms of "maximum nominal tensile stress," that is, without stress concentration factor.

• • Designing for Two Stress Levels

Area of the plastically deformed material has been considered small compared with that in the elastic range; the reason is that the error tends to be on the conservative side. This assumption is satisfactory when designing for a *single* stress level loading condition; however, when used for designing for more than a single stress level, the assumption is uncon-

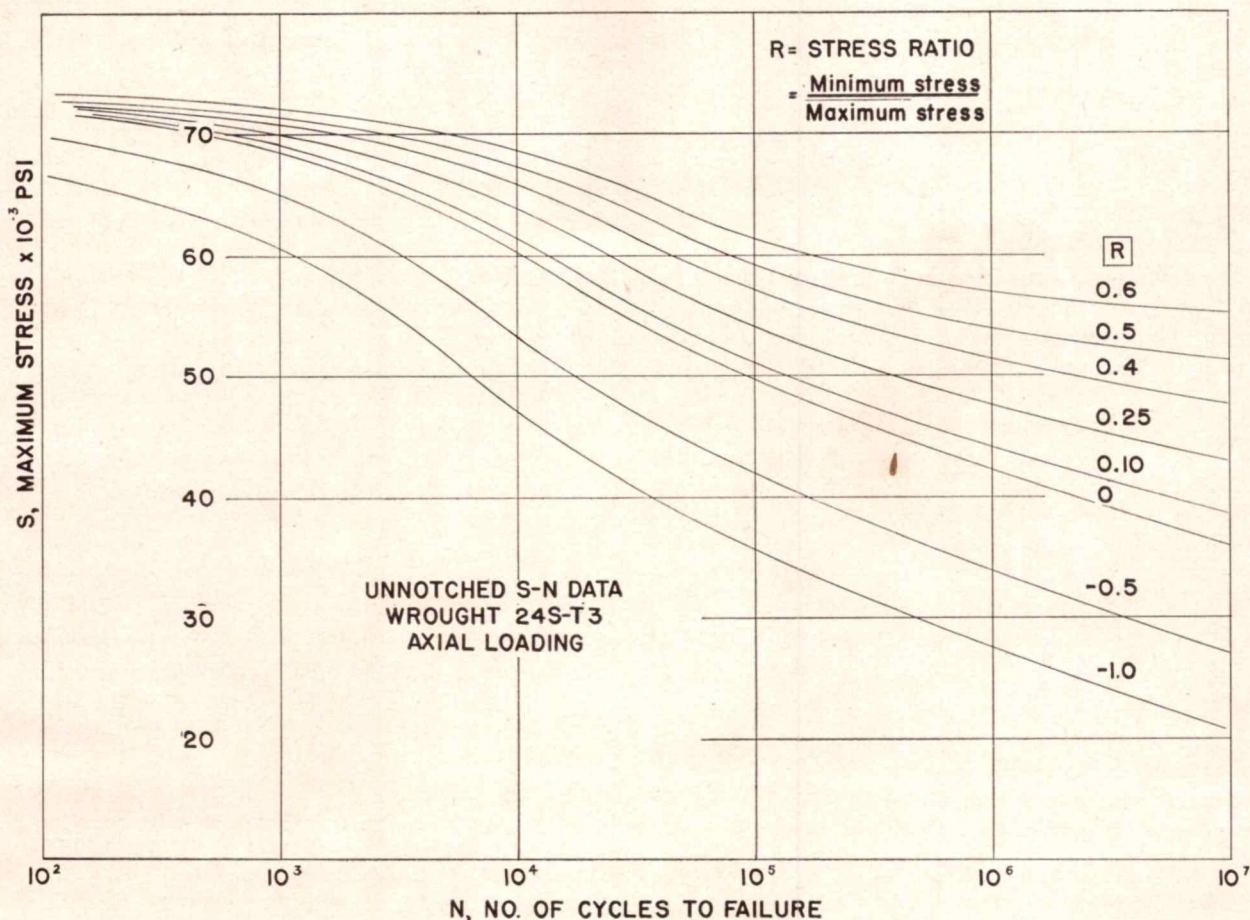


Fig. 4—Stress-strain curves for various stress ratios.

servative. This fact can be illustrated by comparing calculated values with test data at two stress levels. Tests were run at Convair on .064" thick 24S-T3 coupons, $\frac{1}{2}$ " wide and having a single centered $\frac{1}{8}$ " round hole which gave a theoretical stress concentration factor of 2.4. These tests were run at two stress levels: one from 1800 psi to 38,300 psi average net stress, called here the *high level*; and the second from 8750 psi to 31,300 psi average net stress, called here the *low level*. When loaded at the high stress level, the average fatigue life was 18,250 cycles; when loaded at the low stress level, the average life was 92,780 cycles. However, when loaded at the high level for 11.2 percent of the fatigue life at the high level, followed by low level loading, the life at the low level was 46 percent greater than the life of the virgin coupons loaded solely at low level. Similarly, when

the coupons were loaded for 22.35 percent high level life followed by low level loading, the life of the low level loading was 39 percent greater than the life of the virgin coupons loaded solely at low level. When loaded to 45 percent high level, then low level, the coupons experienced a low level life equal to the low stress level life of the virgin coupons. It is stated that for smooth specimens (Ref. 1):

$$\frac{n_1}{N_1} + \frac{n_2}{N_2} + \dots + \frac{n_n}{N_n} = 1, \quad (1)$$

where

- n_1 = number cycles run at high level load,
- N_1 = number cycles to failure at high level load,
- n_2 = number cycles run at low level load,
- N_2 = number cycles to failure at low level load.

Table 1

FATIGUE VALUES BY THEORY AND TEST			
$f_{nom. max.}$	$f_{nom. min.}$	Cycles to Failure	
		(Calculated)	(Test)
38,300	1800	11,000 (N_1)	18,250
31,300	8750	67,000 (N_2)	92,780
31,300	8750	110,000 (N_2')*	no value

* N_2' is number of cycles calculated for low level loading after one cycle of high level loading.

Table 2

NON-DIMENSIONAL FATIGUE VALUES			
$\frac{n_1}{N_1}$	$\frac{n_2}{N_2}$	$\left(\frac{n_1}{N_1} + \frac{n_2}{N_2} \right)$	
	(Calculated)	(Calculated)	(Test)
1 cycle	165%	165%	no value
10%	148%	158%	157%
25%	124%	149%	161%
50%	82%	132%	145%
75%	41%	116%	no value

However for the three cases discussed,

$$\frac{n_1}{N_1} + \frac{n_2}{N_2} = 1.57, 1.61, 1.45,$$

respectively. Thus, for notched materials Equation 1 errs.

● ● Theory Tested

The following calculations are based on the original hypothesis wherein all the residual strain is retained. The expected life is calculated first for the high level loading.

$$f_{nom. \max.} = 38,300 \text{ psi,}$$

$$f_{nom. \min.} = 1800 \text{ psi,}$$

where $f_{nom.}$ = nominal stress. If ϵ = strain, and $E = 10.5 \times 10^6 \text{ lbs/in.}^2$, then

$$\epsilon_{max.} = \frac{38,300}{10.5 \times 10^6} \times 2.4 = 0.0086 \text{ in./in.}$$

Hence, from Figure 2,

$$f_{max.} = 54,000 \text{ psi.}$$

The minimum stress here is represented by all the permanent set being compressed according to assumptions made earlier, plus the minimum positive nominal stress times the concentration factor (see Fig. 3).

$$f_{min.} = -38,300 \times 2.4 + 54,000 + 1800 \times 2.4 = -33,600 \text{ psi,}$$

and therefore

$$R = -33,600/54,000 = -0.62,$$

from which (Fig. 4)

$$N = 7000 \text{ cycles.}$$

Similarly, for the low level loading,

$$f_{nom. \max.} = 31,300 \text{ psi,}$$

$$f_{nom. \min.} = 8750 \text{ psi,}$$

and

$$\epsilon_{max.} = \frac{31,300}{10.5 \times 10^6} \times 2.4 = 0.0072 \text{ in./in.}$$

From Figure 2,

$$f_{max.} = 53,000 \text{ psi,}$$

hence

$$f_{min.} = -31,300 \times 2.4 + 53,000 + (8750 \times 2.4) = -1000 \text{ psi,}$$

and

$$R = -1000/53,000 = -0.02.$$

From Fig. 5,

$$N = 40,000 \text{ cycles.}$$

Now $\left(\frac{n_1}{N_1} + \frac{n_2}{N_2} \right)$ can be compared with the test

data. In view of the beneficial compressive stresses set up by the high stress loading, the subsequent life at low level loading should be calculated on the basis of a new stress level taking into account the residual compression.

Based on the calculations for the fatigue life at the high level loading, the residual compressive stress would be $38,300 \times 2.4 - 54,000 = 38,000 \text{ psi}$. The stress range for subsequent low level loading would amount to $31,300 \text{ psi} \times 2.4$ or $75,000 \text{ psi}$, nominal stress being multiplied directly here by the concentration factor on the assumption that after one high level load the stress rate is linear. Starting at $-38,000$

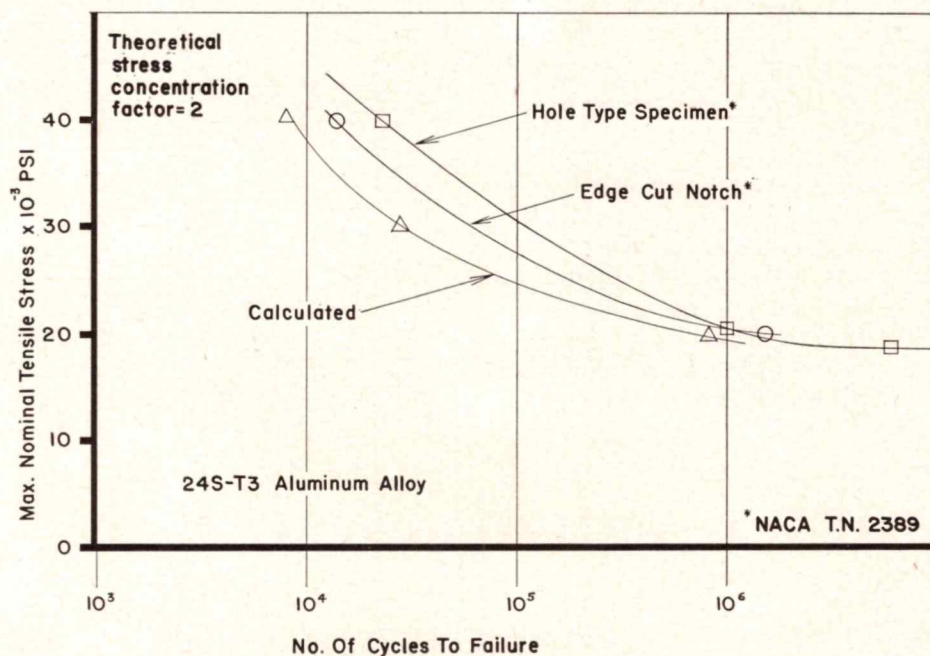


Fig. 5—Comparison at calculated expectancy with actual number of cycles to failure.

psi, the stress would become a peak stress at 37,000 psi. The preload would amount to 8750×2.4 or 21,000 psi. Thus, the new stress range would be from $-38,000 + 21,000 = -17,000$ psi to 37,000 psi. The stress ratio would be $-17,000/37,000$ or -0.46 , and the number of cycles to failure (Fig. 4) 500,000 cycles. Thus, if 50 percent of life is assumed to be expended at the high level loading, followed by low level loading to failure, then:

$$\frac{n_1}{N_1} + \frac{n_2}{N_2} = 0.5 + \frac{500,000/2}{40,000/2} = 13,$$

instead of about 1.5 shown by test.

• • Spring Constant Adjusted

The wide difference between test and theoretical results suggests that the assumption that the spring constant of the elastically deformed metal divided by that of the plastically deformed metal was infinite was wrong, rendering too much benefit from the residual compressive stress as a result of the high level loading. If S_e is the spring constant of the material of the elastic area, and S_p the spring constant for that material suffering plastic deformation, then a ratio of S_e/S_p should be found that could check experimental results. Photoelastic studies show a ratio of 2/1 would be about right for a maximum average net stress of 38,000 psi in 24S-T3, again assuming that the strain rate is linear in the plastic region. The maximum average peak stress was noted here because some of the strain in the area affected by the notch remains in the elastic range, so that the width of area under plastic deformation becomes a function of the maximum stress; for example, if the coupon were loaded to an average net stress of 50,000 psi, the total section would undergo plastic deformation.

Calculations were made using a spring constant ratio of 2/1 with results that were too conservative. Subsequent calculations, assuming a spring constant ratio of 7/3, gave results that approached experimental values. Here, 0.7 of the permanent set was assumed to be retained as residual stress.

Table 1 shows the results of cumulative damage calculations, based on a spring constant ratio (S_e/S_p) of 7/3, along with test data for comparison. The calculations here were made in a manner similar to the examples above, except that 0.7 of the permanent set was assumed to be retained. Table 2 shows the fatigue values in terms of cycle ratios. These data are plotted in Fig. 6.

• • Applications

While the above system points a method of predicting the fatigue life of aluminum structures in general, it should also apply to other metals having similar stress-strain curves. Note that the assumption of the strain rate being linear in the plastic range is apt to be in error by a considerable amount if the slope of the stress-strain curve is steep above the yield strength, unless, of course, tests show that the strain rate in the plastic region is more nearly linear on such materials than on 24S-T3.

The above discussion also points toward other precautions: the use of an infinite spring constant ratio between the elastic and inelastic strains, while satisfactory for the case in which the structure is being designed for loading at a constant level, would

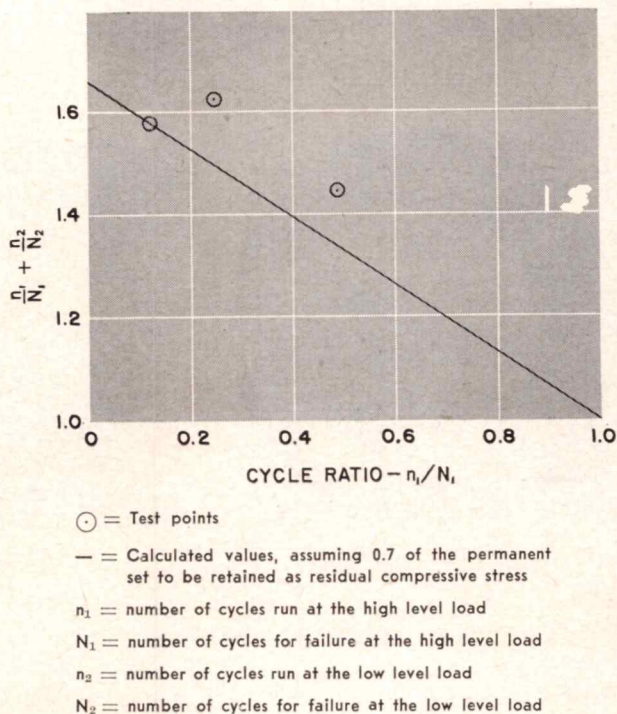


Fig. 6—Fatigue by theory and test.

be unconservative for spectrum type loading. This suggests the use of some spring constant for designing for spectrum type loading that would yield conservative estimates. Possibly the only way to obtain such a value would be to test structures in order to determine a spring constant ratio below which no reasonable design would fall.

For the time being, this method is applicable only for repeated nominal stresses. This is generally suitable for the design of most aircraft structures, since most members experiencing reversals of load do not suffer stress reversals. END

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NEW COCKPIT INSTRUMENTS

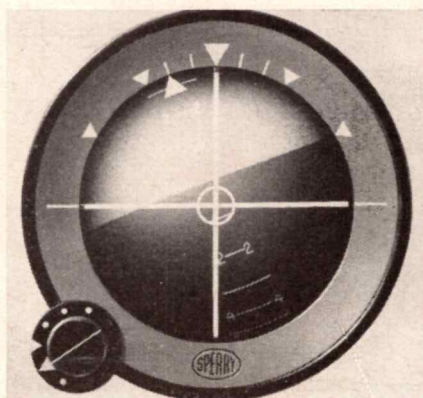


Fig. 1—HZ-1 Horizon Flight Director.

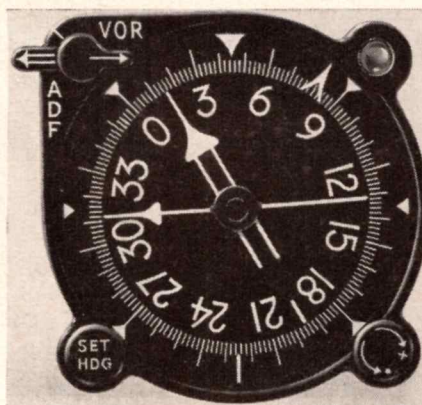


Fig. 2—C-6 Gyrosyn Compass.

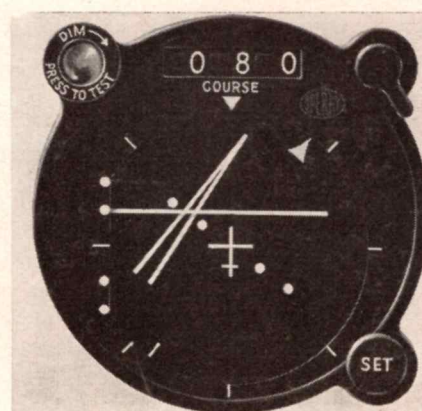


Fig. 3—R-1 Deviation Indicator.

THREE NEW AIRCRAFT panel instruments (see Fig. 1-3), designed to give pilots additional and more pictorial cockpit information for flying present and future high performance planes, were announced by Sperry Gyroscope Company.

Designated the Sperry Integrated Instrument System, these instruments are claimed to provide improved presentation and performance for the gyro-horizon, the direction indicator and the radio deviation indicator. No additional instruments are required over the present "basic six" in common use.

Combining the flight director and the gyro-horizon in one instrument, the HZ-1 Horizon Flight Director element of the system gives the pilot an indication of how to move his controls to seek and follow a desired flight path, and tells him his pitch and roll attitude.

Behind the "fly right or left" and "fly up or down" pointers of the flight director is a "bar-less" horizon sphere that portrays aircraft attitude throughout unlimited maneuvers. Furnishing data to the flight director is a lightweight, tubeless Z-4 Computer that provides more stable coupling to ILS beams during manually-controlled approaches to the runway.

The directional element of the system gives the pilot radio cross-bearing

ings directly on a new C-6 Gyrosyn Compass master dial. A settable course marker on the compass dial helps the presentation for the pilot and also serves as the heading selector for the flight director.

The third element of the system gives a pictorial representation of the airplane's position and heading relative to radio beams. The R-1 Pictorial Deviation Indicator por-

trays the radio beams by means of a narrow converging V-shaped bar that shows pictorially the location of the ground transmitter with respect to the airplane. The new indicator also incorporates an omni-bearing selector by which the pilot can choose any VOR radial bearing to be flown. ILS glide path and localizer deviation are displayed on instrument as on present deviation indicators. END

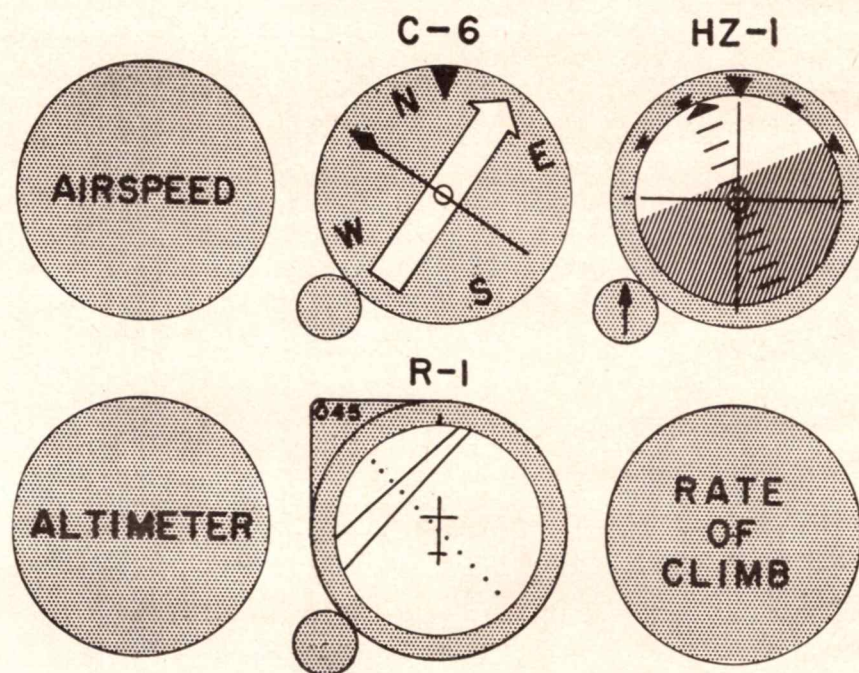
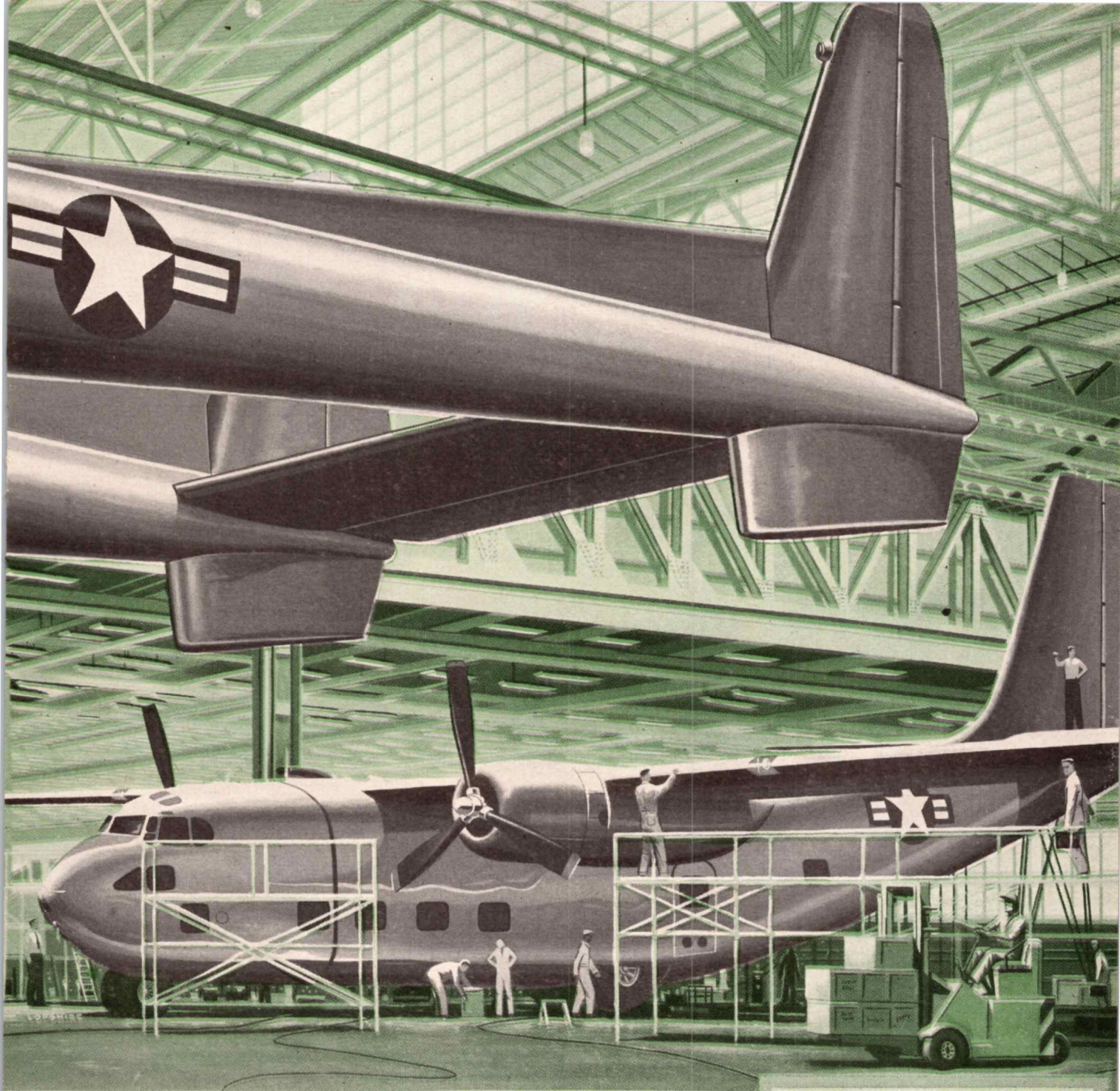


Fig. 4—Three panel instruments of new integrated instrument system fit into simplified panel of "basic six"



SOUND ASSEMBLY

Side by side, they roll off the Fairchild production lines—the famed C-119 *Flying Boxcar* and its new assembly line mate, the C-123 *Avitruc*.

Only Fairchild know-how could have accomplished the swift, sure integration of C-123 production into the C-119 assembly pattern . . . without missing a beat!

The two aircraft make a perfectly matched team of assault transports, created for the single purpose of concentrating maximum numbers of men, machines and equipment in a given area, in the shortest time possible.

It seems altogether fitting that these ultimate developments in assault transports should roll wing to wing from the assembly lines of Fairchild—pioneer in the field of military air transportation.



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Air Force has earned \$100 million dollars for more of these supersonic Voodoos.

F-101A VOODOO

McDonnell's new supersonic fighter



THE F-101A VOODOO, long-range strategic fighter built for the U. S. Air Force by McDonnell Aircraft Corporation, is in the supersonic class, is capable of in-flight refueling and carrying atomic weapons. Model's official designation is *F-101A*.

Dimensions: wing span, 37.7 ft.; length, 67.4 ft.; height, 18 ft. Wings and stabilizer are swept back 35 degrees. Wing skin consists of heavy, tapered, pre-formed sections.

Retractable speed brakes are housed in aft fuselage section. Plane is equipped with a parabrake, a parachute stored in the tail section compartment. The parabrake is released by pilot to reduce landing roll.

Most of the large fuel load carried by the Voodoo is contained in the fuselage; additional provisions have been made for carrying extra fuel externally. Two Pratt and Whitney J-57 turbojet engines power the plane, develop a total of about 20,000 pounds of thrust.

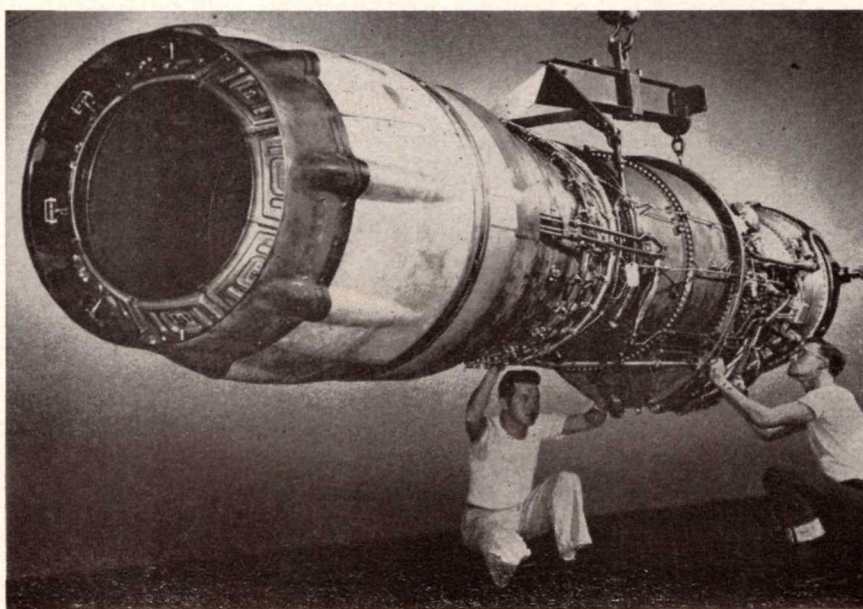
The F-101A is aerodynamic evolu-

tion of an earlier Voodoo model, the XF-88A which made its first flight in October 1948.

McDonnell received a contract for production engineering and tooling of the F-101A Voodoo in January

1952. In September of that year an order was received for production quantities of the fighter. The company also has a contract for the development of a photo-reconnaissance version of the plane. **END**

Two of these Pratt & Whitney J-57 engines power the F-101A Voodoo. The thrust of the J-57, which is in the 10,000 pound class, is increased by an afterburner which is about two feet shorter than other J-57 afterburner types. The exhaust is shown at the left.





technical bulletin

a New *MOTOR*

for hydraulic pump
in a guided missile



EEMCO Model D-638 was designed and produced for a leading airframe manufacturer for use in guided missiles where greatest power output per pound of weight is imperative. Specifications called for a 400 cycle A.C. motor operating on 200 volts, 20 amperes, at 2250 r.p.m. and a continuous duty cycle of 3.0 seconds at 6.5 HP and 15.0 seconds at 1.5 HP. **EEMCO's D-638**, weighing 17.5 lbs., was the answer. It also has a continuous rating at 5 HP of 2300 r.p.m., at 15.8 amperes. Complies with U. S. A. F. specification #32590 for 400 cycle A.C. motors. We invite your inquiry on adaptation of Model D-638 for other uses.

**Designers and producers of motors,
linear and rotary actuators.**

SPECIFICATIONS ★ TYPE D-638

Weight: 17.5 pounds ★ **Maximum Capacity:** 6.5 HP

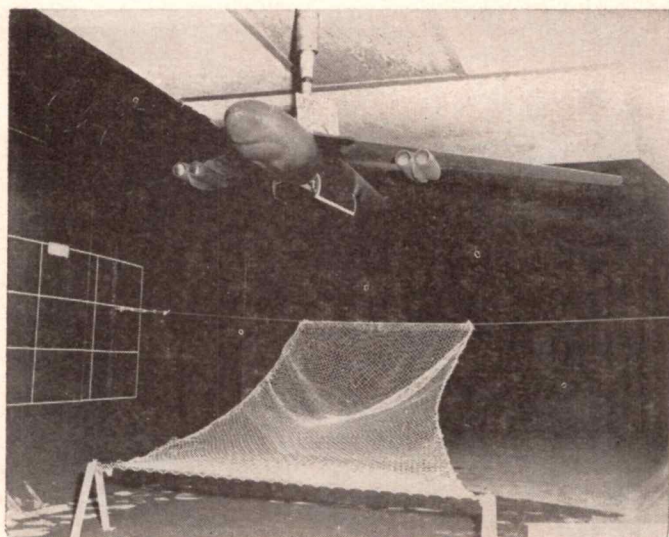
Volts: 200 A.C. ★ **Amperes:** 20 at 6.5 HP ★ **Cycles:** 400

Duty cycle: 3.0 seconds at 6.5 HP
15.0 seconds at 1.5 HP

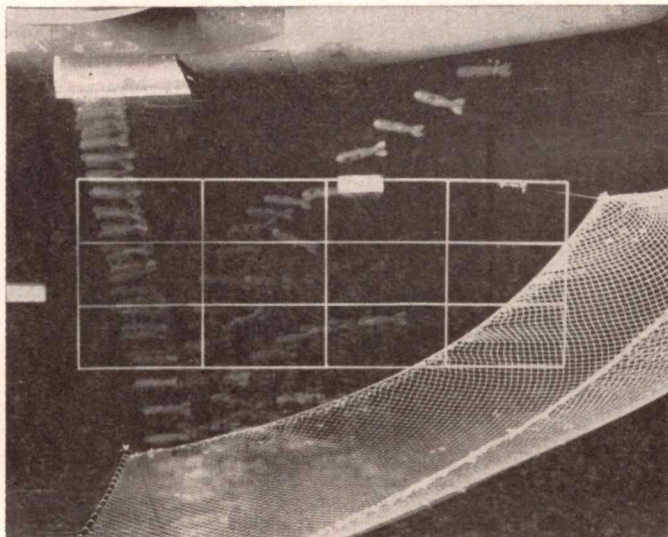
Continuous rating: 5 HP at 2300 r.p.m., 15.8 amperes, 200 volts.

**Electrical Engineering
and Manufacturing Corp.**

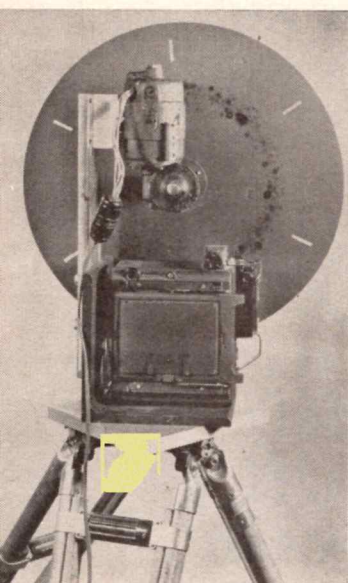
4612 West Jefferson Boulevard
Los Angeles 16, California



BEFORE. Cluster of dummy bombs is about to be salvoed from model of Boeing B-47 Stratojet during wind tunnel bomb test at University of Washington test facility.



AFTER. Dummy bombs have been released. Note that the bomb images to the right of the drop line are bombs that have struck the net and bounced up again.



HIGH SPEED CAMERA for Sequence Photography

**Still camera takes multiple exposures of event
being photographed by motion picture camera.**

CAMERA DEVICE that permits high speed motion pictures to be taken at the same time a still camera is making multiple exposures of the same event has been developed by Boeing Airplane Company to aid in wind tunnel experiments involving bombs, missiles, and droppable fuel tanks.

Nicknamed *Pinwheel*, the device consists of a standard four-by-five Speed Graphic camera mounted against a wheel of sheet aluminum 19 inches in diameter. Into this wheel, which is the key to the camera's high speed capabilities, are cut four beveled slots, each $1\frac{1}{4}$ " x $\frac{1}{8}$ ". The slots are spaced near the wheel's rim

and are set so they pass in front of the camera's lens as the wheel rotates, admitting just enough light to expose the film. A doughnut-like metal plate fits firmly around the lens and against the wheel to serve as a light guide. A 110-volt motor powers the wheel; an attached tachometer measures the speed. The entire device including supporting stand weighs 30 pounds.

In operation, the camera's lens is opened and focused on the model inside the tunnel. An electrical relay system connects the camera to a 5,000-watt spotlight and eight 750-watt spots which illuminate the test section during the drop. These high

powered lights are sufficient to expose the negative each time one of the slots in the wheel passes the lens. With all four slots open, a speed of 0.003 of a second is attained; different speeds may be had by blocking off some slots or speeding the wheel.

The wind tunnel is painted black, and has a white-lined grid painted on the side opposite from where the pictures are taken. The grid is used as a reference for tumble and drift. The bombs are painted white with black crosses, lines, and circles. With these marks at different positions, it is possible to check almost all the acrobatics.

END



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water

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Keeping the world's sea lanes open to our own forces and denying their use to any aggressor is the primary mission of the United States Navy.

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JANUARY 1955

UNDERCOVER

SAILING AERODYNAMICS BY JOHN MORWOOD. 1954, Philosophical Library, New York. 124 pp., \$7.50.

This is the book for aerodynamicists who feel that the modern sailing craft is nothing more than a vertical airfoil with rather poor drag characteristics. To make a yachtsman out of an engineer, the author covers the following material: flow of air around an airfoil; aerodynamic force and conversion to a coefficient; forces acting on boat; hull in the water; comparison of airfoils; the jib; sail balance; the windward and leeward power of sails; evaluation of sailing rigs; possible improvements in rig; sailing with the Bermudian rig; distant effect of sails on the wind; the wind.

GENERAL THEORY OF HIGH SPEED AERODYNAMICS edited by W. R. Sears. Volume VI of *High Speed Aerodynamics and Jet Propulsion* Series. 1954, Princeton University Press, Princeton, New Jersey. 758 pp., \$15.

Theodore von Karman begins the book by outlining the foundations upon which the theories of subsonic, transonic, supersonic, and hypersonic flows have been built. The related problems encountered in the more important applications of these theories are then treated in subsequent sections covering mathematical aspects of hyperbolic flow problems, the small perturbation concept and theory, potential flow theory based on the hodograph method, methods of characteristics, and the analysis of flows with shock waves. Other sections present unified treatment of the subject of linearized supersonic theory, and the use of higher approximations to augment first order theories.

PHYSICAL MEASUREMENTS IN GAS DYNAMICS AND COMBUSTION edited by R. W. Ladenburg, B. Lewis R.N. Pease, and H. S. Taylor. Volume IX of *High Speed*

Aerodynamics and Jet Propulsion Series. 1954, Princeton University Press, Princeton, New Jersey. 578 pp., \$12.50.

In the first part of the volume, which is devoted to physical measurements in gas dynamics, detailed studies of turbulence measurements as well as analog methods using the water table and the hodographic tank are found. The latest studies in the methods of measuring flame temperature, pressure, and velocity along with methods of flame photography are features of Part II. Also included are sections on mass spectroscopy and its uses as a research tool, measurement of burning velocity, and analysis of the combustion wave.

AIRCRAFT RECOGNITION MANUAL by C. H. Gibbs-Smith. 1954, John de Graff Publishers, New York. 239 pp., \$2.50.

Over 200 types of civil and military aircraft of many nationalities, including Russian, are analyzed with photographs and accompanying text.

CANADA'S FLYING HERITAGE by Frank H. Ellis. 1954, University of Toronto Press, Toronto, Canada. 388 pp., \$7.95.

The author's purpose in writing this book was not only to record the significant events in Canadian aviation but also to pay tribute to the "forgotten flyers who flew by guess and by God or with calculated caution—for the sheer love of flying—in the early days."

TABLE OF SINE AND COSINE INTEGRALS FOR ARGUMENTS FROM 10 TO 100. National Bureau of Standards Applied Mathematics Series 32 (reissue of Mathematical Tables 13), 186 pp., \$2.25. (Order from the Government Printing Office, Washington, D. C.)

DYNAMICS AND THERMODYNAMICS OF COMPRESSIBLE FLUID FLOW by Ascher H. Shapiro. 1954, Ronald Press Co., New

York. Volume I, 660 pp., \$16. Volume II, 600 pp., \$16. Both volumes, \$30.

The analytical developments of this book comprise two types of treatments: those leading to design methods and those leading to exemplary methods. The design methods are direct and rapid, and easily applied to a variety of problems. Therefore they are suited for use in the engineering office. The discussions of these design methods are detailed and illustrative examples are often given.

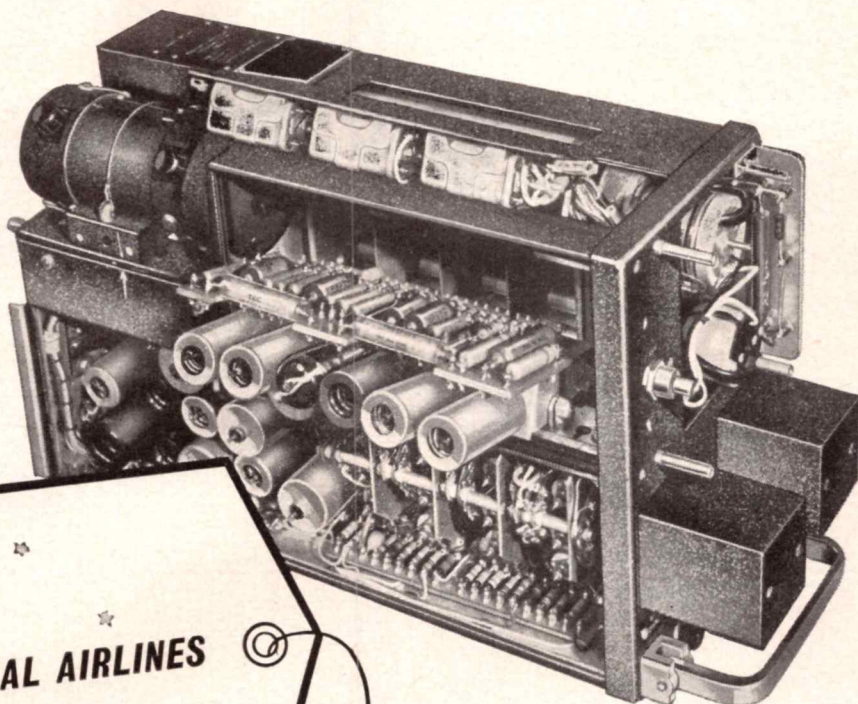
The exemplary methods, on the other hand, comprise those theoretical analyses that are time consuming, that generally require mathematical invention, and that are not easily applied to a variety of problems. Such problems are primarily of value for yielding detailed answers to a small number of typical problems.

GLASS REINFORCED PLASTICS edited by Phillip Morgan. 1954, Philosophical Library, New York, 248 pp., \$10.

The chief resins used for bonding glass fibers—polyesters, phenolic, epoxide, silicone, melamine, and furane—and their use with glass described. Polyesters, being most widely employed, are dealt with in more detail. The many ancillary materials, especially for use with polyesters, and the various forms of glass reinforcements are also described. Properties of the laminates, especially electrical laminates, and commercial molding processes, mass production methods, and the manufacture of tube and rod, are covered in separate chapters.

Further information about the books reviewed in this issue, or copies of the books, may be obtained by writing directly to the publishers indicated.

MARCONI RADIO COMPASS Type AD 7092 C*

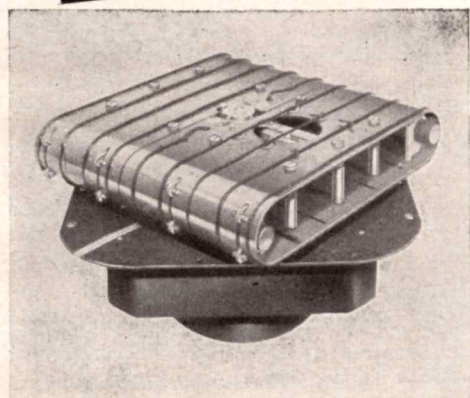


The type AD 7092 C receiver showing accessibility of components.



Specified by Trans-Canada Air Lines and now chosen by Capital Airlines for their Vickers Viscounts.

Marconi Radio Compasses are in service with 40 of the World's leading Airlines.

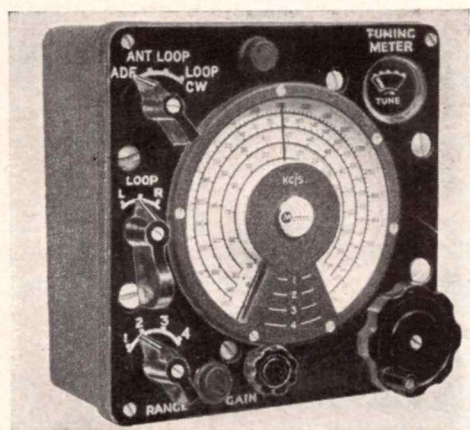


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"Invisible" ramjet pops open for use during take-off and hovering, folds into rotor blade tip during cruise.

RAMJETS IN HELICOPTERS

provide booster power

By R. T. DeVAULT • Project Engineer • Marquardt Aircraft Co.

PRESENT-DAY HELICOPTERS have small payloads compared to fixed wing aircraft of the same power and gross weight, and even this payload is drastically reduced by engine power loss due to high ambient (hot day) temperatures, high altitudes or mechanical difficulties.

This serious problem is caused by the high power required to take-off or hover, which is about twice that required for cruising flight.

If some relatively light powerplant could be used for auxiliary power during the short times spent

in take-off and landing, large economies could result. This idea is reinforced by the plot of maximum power-available and power-required shown in Fig. 1, which indicates a natural opportunity for a power boost system.

One way to get the power boost is to increase the installed horsepower. However, this measure can result in large penalties: in the case of a conventional shaft-power engine, the weight can reach as high as 3.5 pounds per installed brake horsepower.

Adding power at the rotor tip is a more attractive proposition. Tip power produces no torque, no shaft loads, and no cooling problem. In the case of a turbine-powered helicopter, it will allow cruise at a higher percentage of rated power and thereby at a lower specific fuel consumption.

● ● Power Boost at Rotor Tips

Consider the possible weight savings or payload increases promised by a power boost system. Take the case of an existing helicopter with a normal gross weight of 6400 pounds. Now increase the gross weight by adding 1500 pounds of payload, which about doubles the payload. An increase of 150 rotor horsepower will be required. A review of the literature was made to obtain the approximate weights and fuel consumptions of the various systems listed in Table 1. The ramjet data are Marquardt Aircraft Company estimates. The data in the table are not precise, but are qualitatively useful.

The weights of the shaft power engines are high because of weights of transmission, cooling, torque reaction, and auxiliary systems, all of which must increase with shaft power.

It will be noted that none of these weights is so high that the decision on the type of boost power can be made on the basis of weight alone. The pulsejet was not considered here as it could not be seen how the engine could be used as a boost unit; there seems to be no method of making the pulsejet disappear for cruise flight and then reappear when needed. The pressure jet was not considered as it involves major changes in the aircraft engine and rotor systems. However, it is believed that the pressure jet will be a very promising boost system in its developed condition.

Consider now the effect of using

Table I

Weight Penalty Incurred by Addition of 150 Rotor Horsepower

Type of Power Boost	Initial Wt. Lbs	Fuel Rate Lbs/Min	Total Wt. for 10 Min, Lbs
Piston Engine	540	1.4	554
Turbine Engine	440	2.0	460
Augmented Turbine Engine (Water/alcohol injection)	344	12	464
Rocket	70	50	570
Ramjet	45	22	265

Table II

Performance of Helicopter With and Without Ramjet Boost

	Conventional Gas Turbine System	Gas Turbine Plus Ramjet Boost
Rotor power required to hover, rhp	2000	2120 ¹
Turbine-installed power, bhp	2500	1900
Ramjet power, rhp	none	680
Cruise power, rhp	1150	1220 ²
Installed engine weight, lb	10200 ³	7775 ³
Ramjet system weight, lb	none	175
Fuel rate in climb, lb/min	34.2	26 (GT) + 72 (RJ)
Fuel rate for hovering, lb/min	31.4	26 (GT) + 45 (RJ)
Fuel rate in cruise, lb/hr	1280	1150
Duration with one take-off, ⁴ hr	2.82	4.82

¹ A 120 hp penalty was assumed to operate the boost ramjet at a high tip speed.

² A 70 hp penalty was assumed for the drag of the ramjets in their power-off condition.

³ Weight includes weight of transmission and auxiliary system.

⁴ Operation in a climb condition for about 3 minutes, and a power condition equivalent to hovering for about 3 minutes was assumed to constitute one take-off.

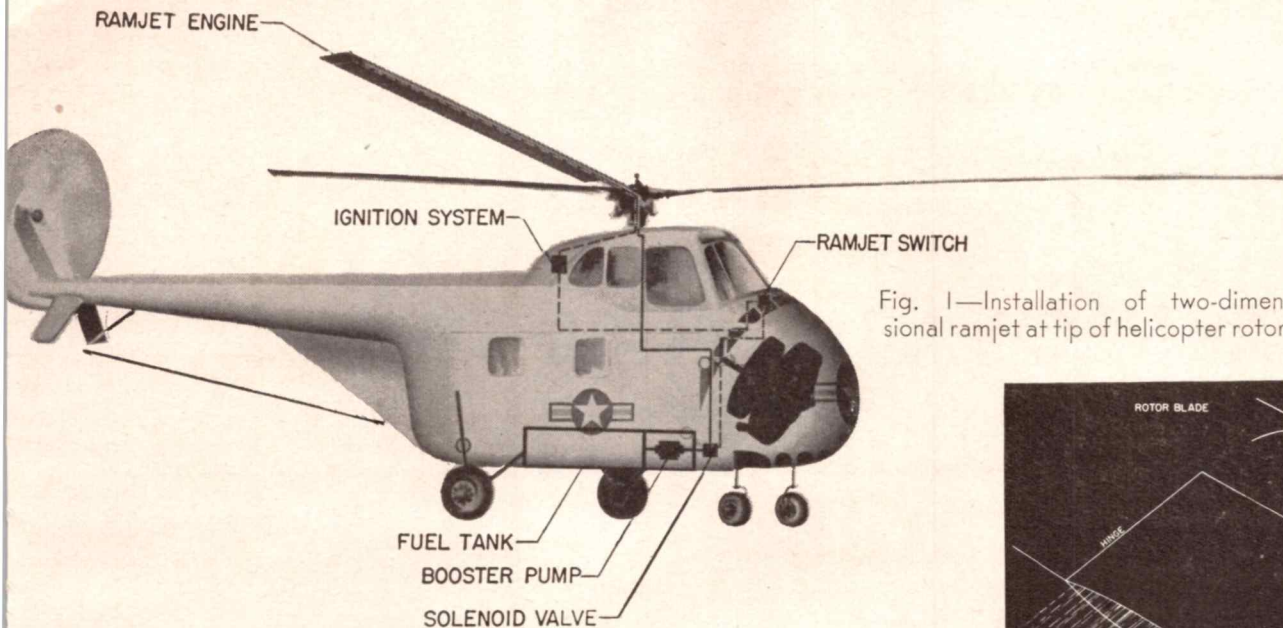


Fig. 1—Installation of two-dimensional ramjet at tip of helicopter rotor.

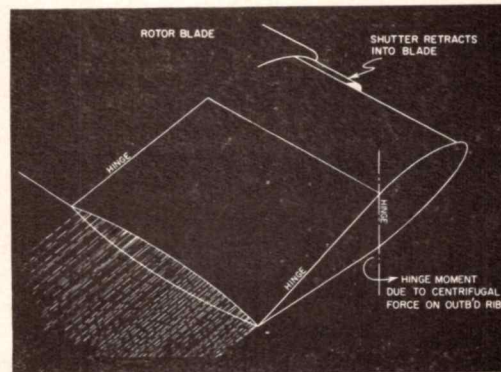


Fig. 2—Variable exit area of ramjet effected by hinges. Note how shutter folds into blade to reveal intake.

ramjet boost power for take-off on the endurance of a large, turbine-powered helicopter. Two power systems are assumed: one a conventional engine installation, and the other a smaller engine in addition to rotor tip-mounted ramjets used for take-off.

Assume that the helicopter weighs 37,800 pounds gross, that the cruise speed is 95 knots, and that the total allowable weight of power system plus fuel is 14,000 pounds. Estimated data comparing the two systems are tabulated in Table 2.

The data of Table 2 indicate that a ramjet power boost system offers much in the way of increased payload and flight duration. However, there are other conditions that the ramjet must meet and overcome before it can be seriously employed. As an example of some of these conditions, the system must be simple, reliable, failsafe, easily maintained, and fairly quiet.

● ● Ramjet Design

The design problem has some formidable barriers to theoretical analysis. The flow at the rotor tip is

three-dimensional, rotational, viscous, compressible, and unsteady. The potential fuel pressure varies across the engine, and the fuel spray and the air flow in the engine are subject to centrifuging. There is one fortunate fact: the engine is required to operate only over a very narrow range of flight conditions. Tip Mach number, angle of attack, altitude, and power required vary only slightly, and all the time derivatives are small. The boost system engine operates only under take-off or hovering conditions and is shut off during transition to forward flight.

The engine design, in order to be attractive to the helicopter industry, must be severely compromised. It was decided that the engine geometry would be limited to typical rotor blade dimensions. Development progressed on an engine 16½" long, 2½" thick, and 15" span. The engine simply replaces 15 inches of rotor blade at the tip. This makes it possible to integrate the engine with the rotor blade, aerodynamically and structurally.

The present folding concept is illustrated in Fig. 2. The aft skins on

the engine are hinge-supported on three sides; the outboard rib has a vertical hinge in line with the front skin hinge. The exit area is thus controlled by a balance of forces between the engine internal pressure and the centrifugal load on the outboard rib. A shutter slides across the inlet in the power-off condition, decreasing the internal pressure and allowing the centrifugal force on the outboard rib to pull the exit shut.

Figs. 3 and 4 show views of the static test model. A rotating shutter is used to close the inlet in this model, but a sliding shutter of the type shown in Fig. 2 is to be used in subsequent models.

Results to date have been good. No insoluble problems have been met. A 22-foot radius rotor is expected to be ready for Whirl Stand Test this month. END

Fig. 3—Static test model of flexible skin ramjet. Rotating shutter shown in foreground to be replaced by sliding shutter.

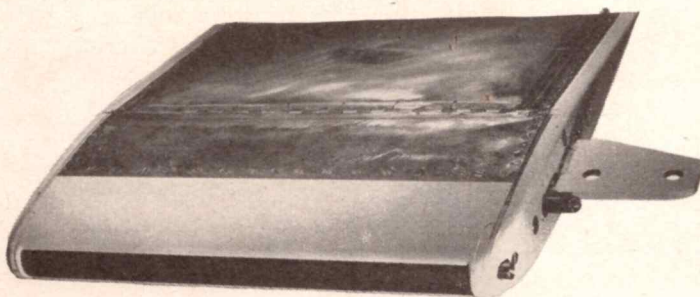
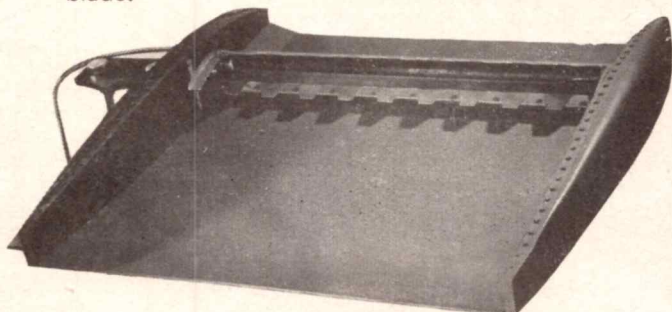


Fig. 4—Two dimensional ramjet with top skin removed to reveal flame holder, fuel nozzles and firing plug. This is a working test model and does not incorporate hinge arrangements that permit engine to fold into rotor blade.



PLASTICS IN AIRCRAFT

DISPOSABLE FUEL TANKS

By SAMUEL S. OLEESKY

Plastics Editor

USE OF AUXILIARY TANKS to increase range was a war-born device. Droppable, or jettisonable, fuel tanks were fitted to many fighter planes to assist them in accomplishing missions not otherwise attainable. However, *more aluminum was used for jettisonable tanks during the past war than was expended by the entire airframe industry for fuselage construction.* This, of course, just about wrought havoc with the critical materials procurement program. A second defect in the program of using metal tanks was the fact that every tank dropped over enemy territory provided the enemy with salvagable scrap metal, which could be thrown back at the allies.

● ● Plastic Tanks

Jettisonable tanks fabricated from reinforced plastics have been tested and found completely acceptable. Plastics do not represent a highly critical material. During the last war, a temporary shortage of styrene threatened for a time to cut down on the production of polyester resins, so that the synthetic rubber program would not be hampered. It is not likely that such a condition will exist again. The other component of the reinforced plastics tank is glass, in fibrous form. The ingredients of glass, which are sand and lime, will not soon become critical. Thus, in the plastic tank, one has an item that consumes no critical metals. In addition, the tank is stronger, on a weight basis, than metal. Finally, in dropping a plastic tank over enemy territory, the pilot provides the enemy with nothing reclaimable.

A typical set of properties and advantages of these tanks is as follows:

Light weight. The approximate

weight of a 450-gallon tank is 175 pounds, less than 0.4 pounds per gallon of capacity. This represents an appreciable weight saving over comparable metal tanks.

Non-critical material.

Inert components. Reinforced plastics are impervious, and resistant to attack by salt water, fungi, aircraft fuels, and corrosion. Good resistance to environmental conditions, such as extreme temperature, is also inherent.

Ease of maintenance. Reinforced plastics may be repaired readily in the field with materials requiring no heat or pressure for adequate bonding. Punctures may be sealed in a manner similar to patching a tire.

Minimum leakage. All joints are sealed with a flexible bonding material that permeates all minute openings thereby providing a leak-proof joint and a structurally sound bond.

High production. Because of the ready availability of materials and the techniques of pre-form molding, almost unlimited production rates may be maintained on tooling and machinery, which are readily procured.

Flexibility of design. Within obvious limitations, these tanks may be produced in almost any aerodynamic shape with minimum effect on weight, cost, or rate of production.

Low cost. Because of simpler tooling, minimization of labor, reduced space requirements, and higher production rates, cost of reinforced plastics tanks

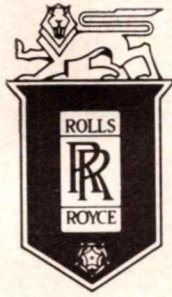
is competitive with that of metal counterparts.

Many molding techniques are used by the plastics industry, and most of these produce parts of the same general properties. However, close quality control is essential, and production of items as critical as fuel tanks should not be attempted by any group without adequate facilities or experience. This remark is primarily aimed at recent suggestions proposing that wing tanks be produced in the field on portable equipment. The latter proposal is based upon some successful work that was done in the field with plastic pipe extruding machinery. Resins used in reinforced plastics are not the same as those used in extrusion work. Polyesters, epoxies, and phenolics are highly sensitive to temperature variation during their uncured stages. Dust, high or low relative humidity, shelf life, catalysts, and many other factors can seriously change the properties of the molded part.

● ● Nestability

An advantage not previously covered is that of "nestability." When properly designed, these tanks may be shipped in crates, with sections nested and ready for field assembly. Distinction should be made between assembly and molding. In assembly, all that is required is the application of a structural adhesive, furnished ready for use in kit form. Normally, a knocked-down tank can be assembled in less than two man-hours. Nestability ratios run as high as ten to one. This means that, for shipping purposes, ten tanks could well occupy little more space than one assembled tank.

END



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REINFORCED PLASTIC REPLACES ALUMINUM

Plastic cover plate

- solves high frequency vibration problem
- is easily molded
- is lighter in weight

By F. S. SWACKHAMER

Manager, Resin and Plastics Dept.
Shell Chemical Corporation

FATIGUE FAILURE from continuous vibration is quite familiar to every aircraft designer. The Propeller Division of Curtiss-Wright has recently solved this problem in connection with a propeller cuff cover plate.

The propeller cuff (Fig. 1) is made of aluminum alloy, reinforced top and bottom with aluminum doublers. A rubber sealing strip is incorporated at the outboard edge of the cuff, permitting a close fit around the propeller blade. The cuff flares out to the propeller shaft and is clamped to the blade root. To reduce wind resistance and turbulence, a cover plate is used to close off the inboard end of the cuff.

The plate used formerly was a single piece of sheet aluminum alloy, 1/16-inch thick, reinforced with aluminum doublers at the mounting edges. Experience showed that it was susceptible to fatigue; after long periods of operation under severe vibration it cracked at the point of attachment to the propeller cuff.

● ● Reinforced Plastic Used

To overcome this difficulty, Curtiss-Wright needed a material with satisfactory physical properties and greater flexibility to absorb the vibrational load. One of the new materials selected for investigation was a

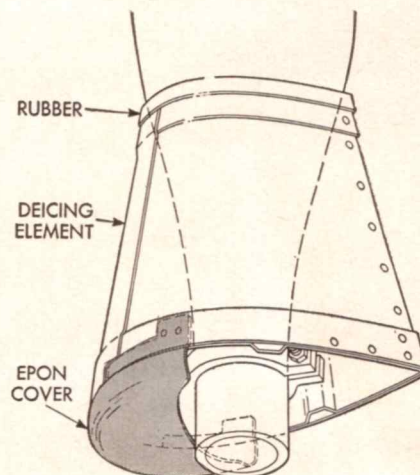


Fig. 1—Sketch of propeller cuff, showing location of leading edge cover plate.

reinforced plastic composed of epoxy resin Epon 1001 and glass cloth.

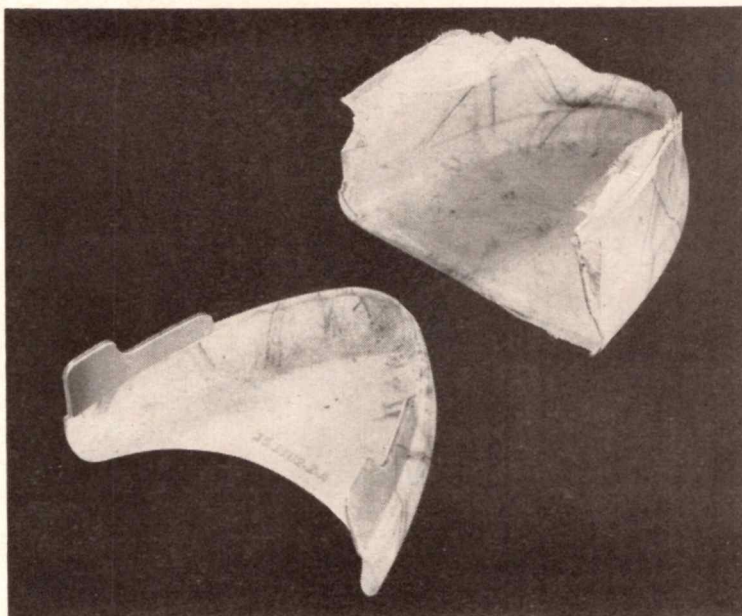
The first step was that of finding a suitable method for forming the resin-based cover plate. Fig. 2 shows that the vertical sides of the cover plate bulge towards the outside. Because of this bulge, matched metal molds could not be used. Instead, a steel cavity was prepared, and a rubber plunger fitted to it. This plunger exerted pressure against the inside of the cuff cover plate until the curing resin had set, after which the flexible plunger was easily removed. (See Figs. 3a-b.)

Once a proper mold had been designed, tests were run to determine the temperature, pressure and curing cycle required to give the desired toughness and flexibility. As each piece came out of the mold it was checked in a vibration testing apparatus until it either cracked or broke. Thus, the rubber and plastics laboratory quickly found that curing the part at 300 psi and 320°F for about 15 minutes yielded optimum characteristics.

● ● Production Procedure

In the first production step several layers of glass cloth were tailored to fit a suitable mold, Fig. 4.

Fig. 2—Left, reinforced plastic cover plate with aluminum doublers cemented on. Right, same cover plate, fresh out of the mold.





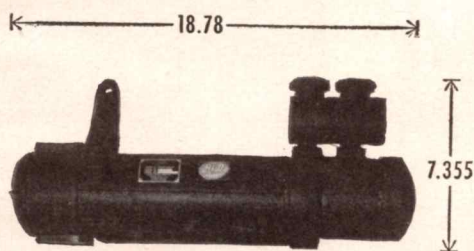
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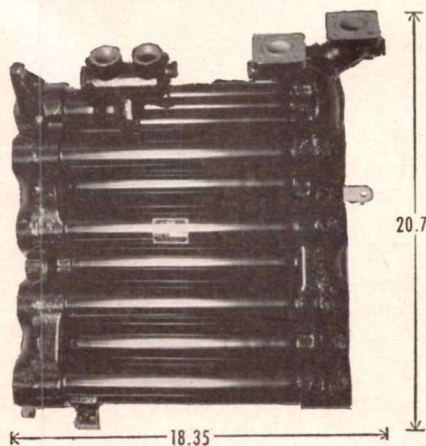
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This cloth was ready-to-use as soon as received since it had been pre-impregnated with resin, dicyandiamide curing agent, and accelerator. The rubber plunger was slid into position, mold closed, and pressure and heat applied until reinforced plastic cover plate was cured.

After leaving the mold, the cured part was trimmed to final shape. Machining was easy and left no frayed edges or pores to allow moisture penetration. Aluminum doubler plates were then cemented to the two flange sections with an adhesive that was cured under contact pressure at 250°F for 45 minutes. Before assembly, holes were drilled into the flanges and nuts affixed so that cover plate could readily be mounted onto the propeller cuff.

Inasmuch as the specific gravity of the reinforced plastic cover plate is approximately 1.85, while that of aluminum is about 2.77, the reinforced plastic made a noticeably

lighter part. Also, since the plastic cover plate could be built up to varying thicknesses as dictated by structural needs, it was not necessary, as was the case with aluminum cover plates, to use 1/16-inch sheet throughout simply because this thickness was required at one point.

Use of different thicknesses at various sections not only reduced weight but also contributed to the unusual fatigue resistance of the part. For instance, at the point of attachment to the propeller cuff, high strength and rigidity was obtained with 14 layers of the resin-impregnated glass cloth. Conversely, for the web of the piece, which required less strength but greater flexibility, only 6 layers were used.

● ● Fatigue Test Results

A vibration test was devised to predict how long, comparatively, cuff plates made of various materials might stand up. The part was vi-

brated at high frequency with one edge clamped in the apparatus and the free end having a total amplitude of 3/8 of an inch. If the part did not fail before the first ten hours of test, the amplitude was increased by 1/8-inch increments until the part cracked or broke.

The cover plates made of reinforced plastic did not break even when the total amplitude of the free end had reached one inch. In fact, in order to boost the amplitude beyond this point and test to destruction it was necessary to attach a small weight to the free end. It was possible to achieve an average amplitude of 1 3/4 inches before the plastic parts failed. This was far beyond any operating strain the cover plates would encounter.

It is generally understood that a test of this nature cannot predict the exact number of hours that a part will last in service. However, it did show qualitatively that the reinforced plastic cover plate, vibrating at successively higher intensities for some 120 hours, could stand up longer than an aluminum part of the same design, which failed after less than ten hours. Service tests conducted on aircraft in flight, with temperatures varying from about -40°F to 150°F, bear out this conclusion. Not one of the reinforced plastic parts in use has shown any signs of failure, and some of them have logged well over 1,000 hours of flight time.

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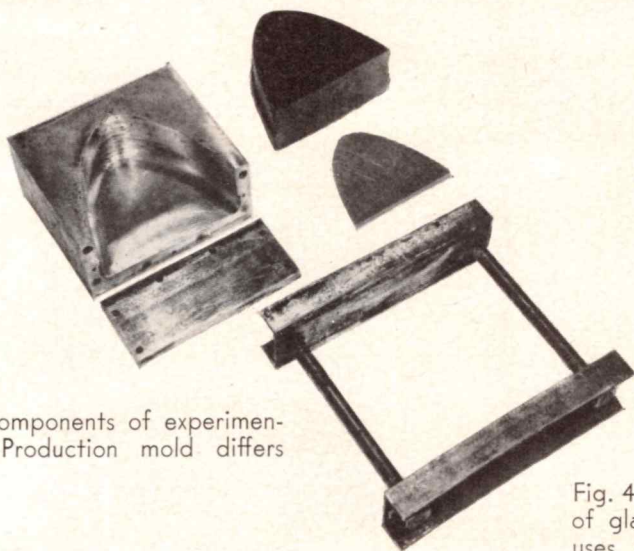


Fig. 3a—Components of experimental mold. Production mold differs slightly.

Fig. 3b—Experimental mold in closed position.

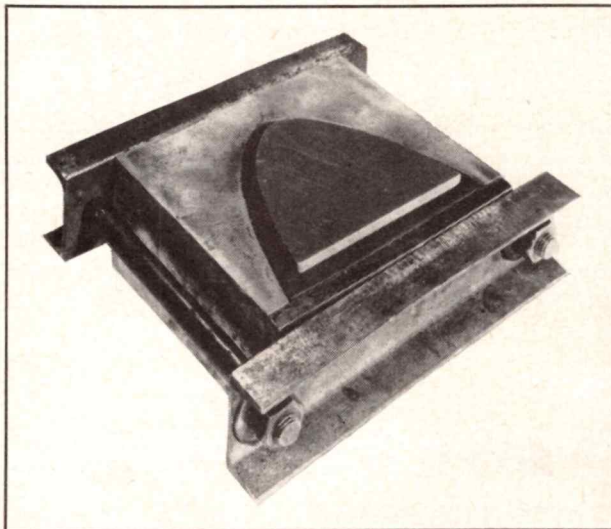
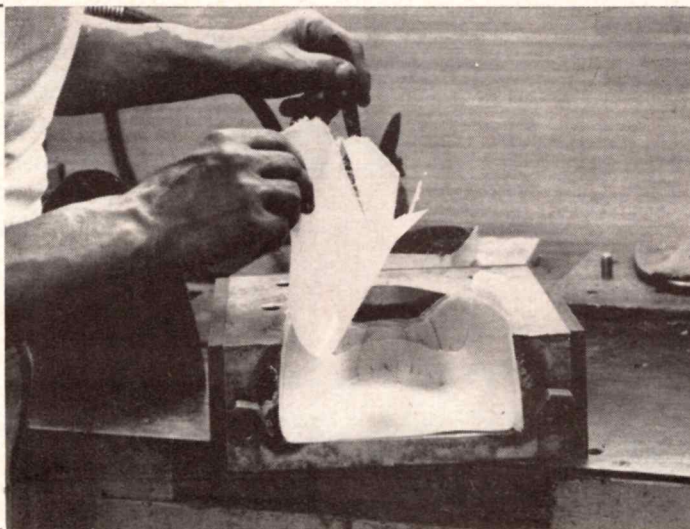
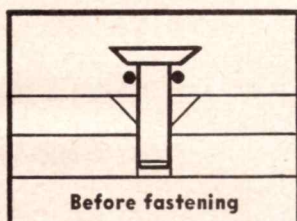
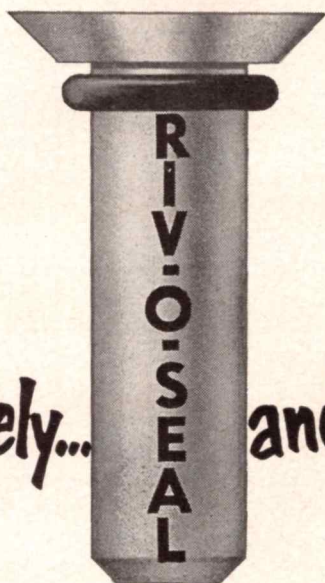


Fig. 4—Operator laying up several thicknesses of glass-reinforced Epon resin sheets. Web uses fewer layers than flanges to provide greater flexibility.

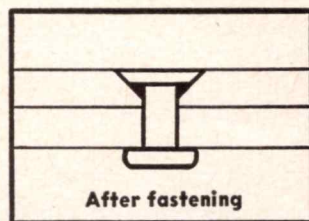


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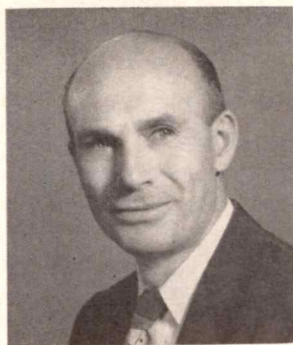
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Names in the News

H. M. Horner, President of United Aircraft Corporation, Hartford, Conn., is the new Chairman of the Board of Governors of the Aircraft Industries Association of America. He will serve during the first half of 1955. **J. C. Garrett**, President of the Garrett Corporation, Los Angeles, Cal., was elected Chairman of the Board for the second half of the year at the regular winter meeting of the Board recently in Phoenix, Ariz. **John P. Gaty**, Vice President of Beech Aircraft Corporation, was elected a new member of the AIA Board and Chairman of the AIA Utility Airplane Council.

Dr. Theodore Theodorsen, a leading scientist with the Air Research and Development Command of the Air Force, has joined the Fairchild Engine Division of the Fairchild Engine and Airplane Corporation as a consultant. Appointment was announced by **George F. Chapline**, Fairchild Vice President and General Manager.



Dr. Neil W. Lamb

Dr. Richard W. Porter, General Manager of the General Electric Company's Guided Missile Department, has been elected President of the American Rocket Society.

Dr. Neil W. Lamb has been named Long-Range Planning Administrator for Convair Division of General Dynamics Corporation, San Diego.

Myron G. Domsitz has been appointed Chief Engineer of Simmonds Aerocessories, Inc., by **W. R. Enyart**, Company President.

Thomas E. Flannigan, Northrop Aircraft, Inc., Military Relations Specialist, has been named assistant

to **John W. Myers**, Vice President of Northrop's Customer Relations.

Lieutenant General Harold L. George is the new Senior Vice President of the Ramo-Wooldridge Corporation, it is announced by **Dr. Dean E. Wooldridge**, President. **Dr. Bernard Rasof** has joined the company's Guided Missile Division as a mathematician and aeronautical engineer and **Frank W. Lehan** as an electronics research engineer.

Creation of two new positions in the Pilotless Aircraft Division and transfer of an additional top level engineer to the organization was announced today by **Wellwood E. Beall**, Boeing Airplane Company Senior Vice President. **Robert H. Jewett** has been appointed Chief Engineer of the Division, **George Snyder** is the Chief Project Engineer, and **William H. Cook** is Chief of the Technical Staff. Boeing now has more than 2,000 persons in the Pilotless Aircraft Division.

William H. Kushnick has been appointed Executive Director of the Instrument Society of America, with headquarters in Pittsburgh, Pa. **K. R. Duce, Jr.**, is the new Sales Manager of the Safe Flight Instrument Corporation, White Plains, N. Y., it is announced by **Leonard M. Greene**, Corporation President.

Malcolm P. Ferguson, President of Bendix Aviation Corporation, announces that **E. K. Foster** has been named a group executive in charge of four divisions—Bendix Radio, Bendix Television and Broadcast Receiver, York, and Cincinnati.

S. E. Knudsen has been named Manufacturing Manager for Aircraft Engines Operations it is announced by **Harold H. Dice**, Assistant General Manager and Manager of Aircraft Engines Operations, Allison Division, General Motors Corporation.

Edwin J. Nilsson has been appointed Eastern Sales Manager for the LearCal Division of Lear, Incorporated, by **Henry J. Hamm**, Commercial Sales Manager. Mr. Nilsson will headquarter at Teterboro, N. J.

Three new executive appointments at Convair, a Division of General

Dynamics Corporation, are announced by **B. F. Coggan**, manager of Convair-San Diego. **A. W. Morgan** is the new Assistant Manager-Operations (San Diego), **George A. Covington** is Assistant to the Manager, and **Roy H. Gilliland** the Manager of Quality Control.



Tibor F. Nagey

Martin Aircraft has established a Nuclear Division and **Tibor F. Nagey** is its Manager. The Division plans to develop nuclear reactors and related components for military, industrial and commercial use.

Lee B. Johnson, Chief Safety Engineer of Northrop Aircraft, Inc., has been elected President of Veterans of Safety, an international safety organization.

Edward L. (Swanee) Taylor, veteran aviation writer, pilot, instructor and air meet master-of-ceremonies, has been given the Diploma of Honor of the International League of Aviators, it is announced by **Colonel Charles W. Kerwood**, League President. Mr. Taylor is presently a patient in the National Institute of Health, Bethesda, Md.

Dr. Herbert C. Corben, internationally-known research scholar and physicist, has joined the staff of The Ramo-Wooldridge Corporation, Los Angeles electronic research and development firm, as physicist in their Guided Missile Division. **Dr. Millard V. Barton** has joined the same division as an Engineer and **Dr. Wendell A. Horning** as a Physicist.

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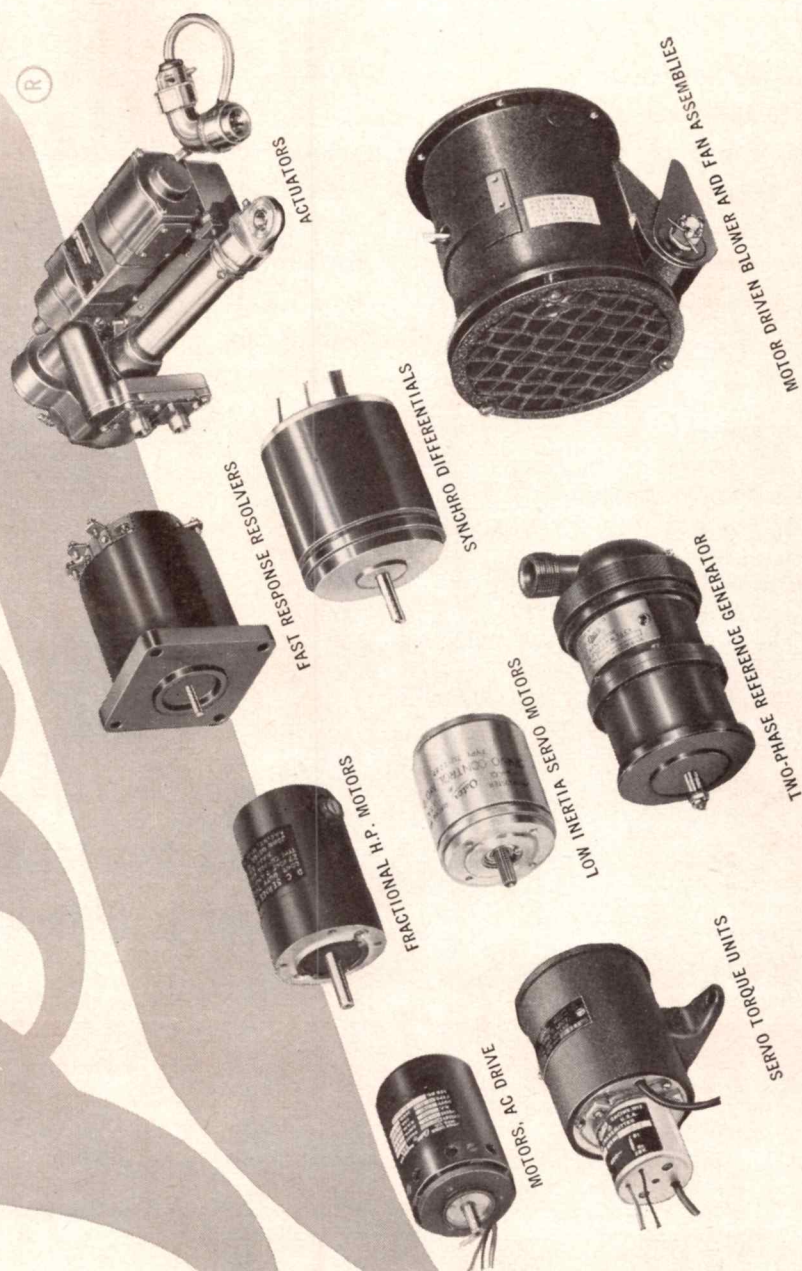
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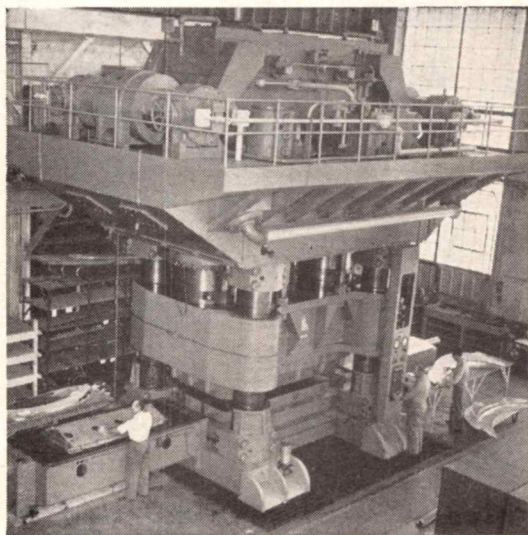
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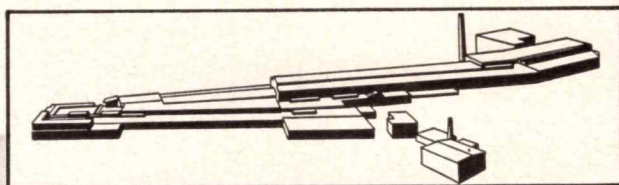
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for Lear, Incorporated, Santa Monica.

James E. Scott has been appointed Assistant Manager of the Aircraft Sales and Contracts Department of the Allison Division of General Motors by **Harold H. Dice**, Division General Manager.

LaMotte T. Cohu, former President and General Manager of Convair, has been appointed Chairman of the Board of Kay Lab of San Diego, manufacturers of a varied line of electronic precision instruments for industrial use.

Robert W. Bowman has been appointed Chief Industrial Engineer of Aeroquip Corporation, Jackson, Mich., by **Matthew J. Betley**, Vice President and General Manager.

Lawrence A. Hyland is appointed Vice President and General Manager of the Hughes Aircraft Company by **Howard Hughes**. Mr. Hyland was formerly Vice President-Engineering of Bendix Aviation Corporation.

W. J. Kinsey is the new Sales Manager of Engine Controls for the General Electric Company Aircraft Products Department. Appointment was announced by **S. W. Upham**, manager of Marketing for the Department.

Arthur E. Harrison has been named Director of Engineering for the Fairchild Guided Missile Division by **Edwin A. Speakman**, General Manager.

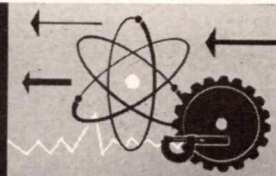
John A. Drake is the new Director of Long Range Planning and Research Programs for the Marquardt Aircraft Company, Van Nuys, Calif., it is announced by **Roy E. Marquardt**, Company President.

Captain John W. King, U. S. Navy (Ret.), has joined Power Generators, Inc., Trenton, N. J., as Executive Vice President.

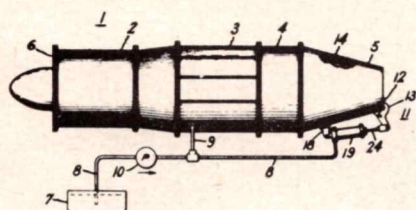
James P. Buckley has been named to the new post of Regional Sales Manager on the West Coast for four divisions of Bendix Aviation Corporation, it is announced by **Raymond P. Lansing**, Vice President.

L. R. (Mike) Hackney, formerly Executive Vice President of the Transport Air Group, Inc., has been appointed Administrative Assistant to General Manager **W. L. Landers** of the Fairchild Aircraft Engine and Airplane Corporation.

THE TREND OF INVENTION

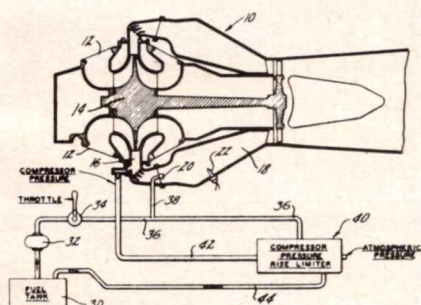


Control device for gas turbines having fluid injection augmentation systems (2,694,289). J. S. Alford, Nahant, Mass., assignor to General Electric Co.



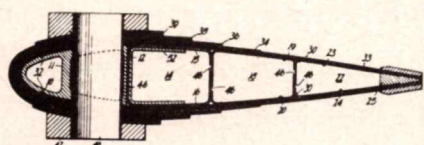
A variable flow area nozzle in the exhaust of a turbojet engine, means for connecting the pressure to the variable flow area nozzle, and means for decreasing the variable area with an increase of pressure.

Regulator for limiting compressor pressure rise (2,694,290). S. G. Best, Manchester, Conn., assignor to United Aircraft Corp.



A gas turbine engine having a means for by-passing a portion of the fuel from the throttle valve to the combustion chamber.

Rotor blade construction (2,694,458). E. W. Stevens, Snyder, N. Y., assignor to Bell Aircraft Corp.

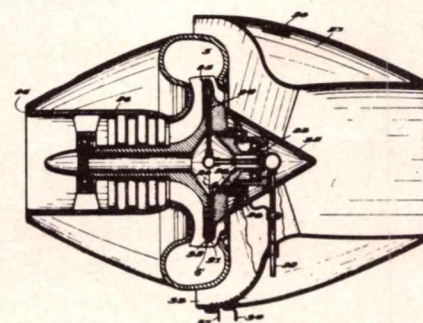


A hollow rotor blade having cells extending longitudinally in side-by-side relation, one cell comprising an integral hollow metal extrusion having a surface portion forming the shape for the leading edge.

Variable pitch propeller control latch mechanism (2,694,459). D. Biermann, Piqua, O., assignor to Hartzell Industries, Inc.

Resiliently acting means connected with the propeller blades to rotate them in one direction, centrifugally acting means for rotating them in the opposite direction, and a mechanism to prevent operation of the centrifugally responsive means when propeller speed is above a predetermined speed.

Rotor and combustion chamber arrangement for gas turbines (2,694,291). H. C. Rosengart, Trollhattan, Sweden.

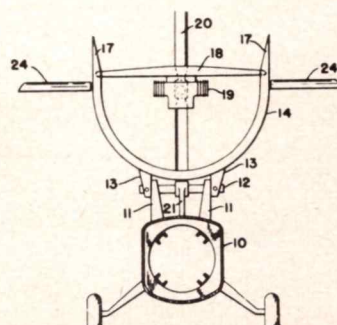


A gas turbine engine having fuel jets positioned peripherally on the rotor blades and so directed inwardly of the combustion chamber as to spray fuel within the chamber.

Air-conditioned aircraft (2,694,537). J. B. Reichert, Berkeley, Calif.

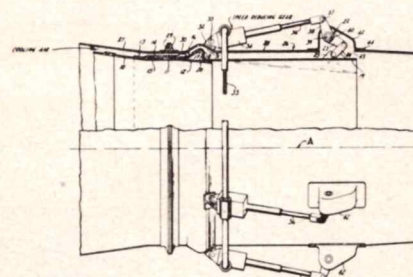
An air inlet including a duct open and terminating at the exterior of the fuselage tail portion and discharging inlet air into the fuselage, and an air outlet extending from the interior of the fuselage and terminating at the exterior of the body and opening laterally of the fuselage.

Adjustable lift-propulsion device for aircraft (2,693,920). C. G. Taylor, Alliance, O.



An aerodynamic device having a channel for the passage of a slipstream, and means for impelling a stream of air through the channel to provide lift on the airfoil, and means for turning the airfoil and impelling means as a unit, about the hinge axis of the assembly.

Adjustable nozzle for exhaust gas (2,682,147). H. H. Ferris, Jr., San Diego, Calif., assignor to Rohr Aircraft Corp.



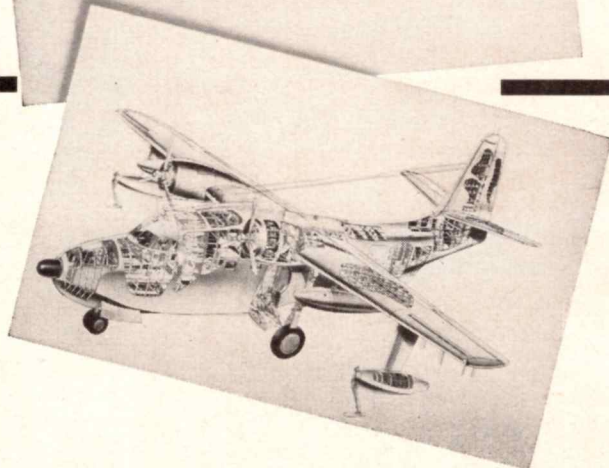
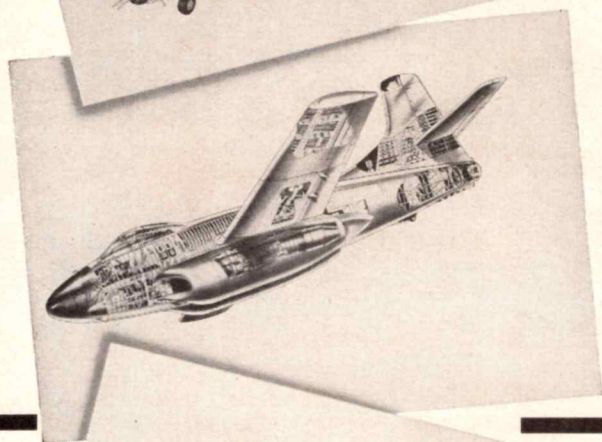
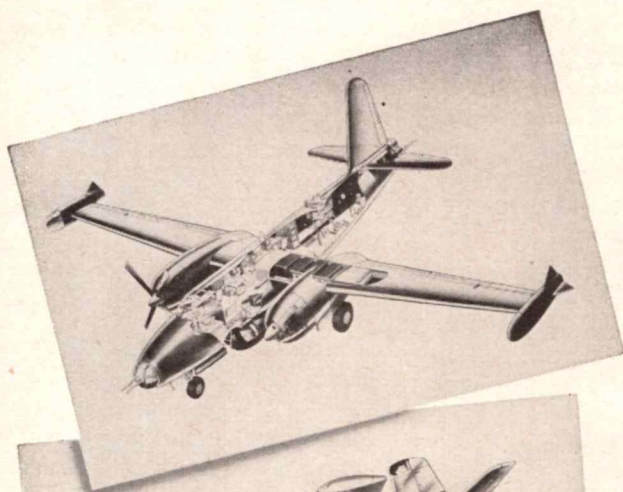
A shroud surrounding the tail pipe and flaps, spaced to permit the passage of cooling air along the outside, and means for inwardly moving the downstream ends of the flaps to decrease the nozzle orifice.

These patents appeared in recent issues of the U. S. Patent Office Official Gazette. Printed copies of the patent may be obtained free of charge on your company letterhead from Technical Editor, Aero Digest, 515 Madison Ave., New York 22, N. Y.

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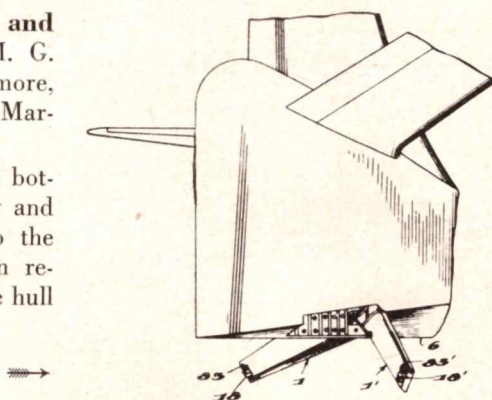
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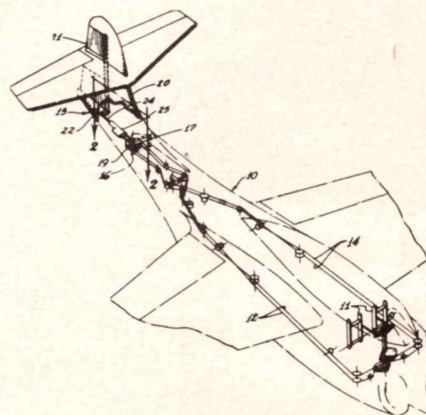
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Combined aircraft hull and water rudder (2,691,497). M. G. Scheider and I. E. Kass, Baltimore, Md., assignors to The Glenn L. Martin Co.

A steering device having a hull bottom with sides sloping inwardly and downwardly from the chine to the keel with a rudder forming, in retracted position, a portion of the hull bottom.

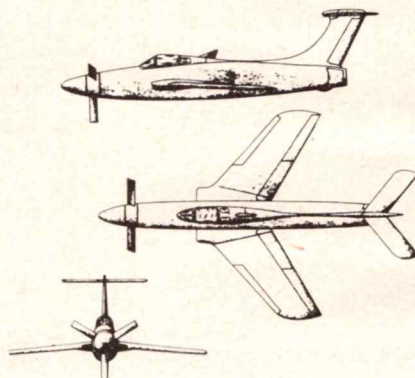


Stable power control for aircraft (2,694,536). T. A. Feeney, Los Angeles, Calif., assignor to Northrop Aircraft, Inc.

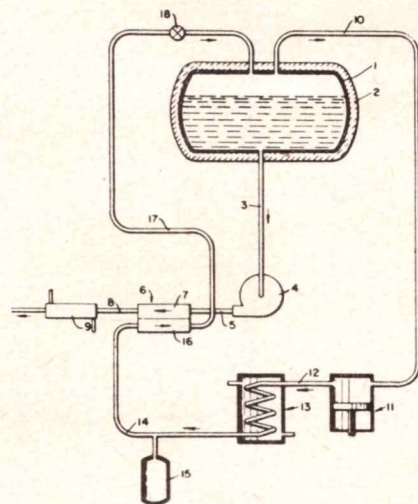


A hydraulically powered surface control system in which a valve directs operating fluid in a piston to operate the surface.

Airplane design (1,734,911) A. Kartveli, Huntington, N. Y., assignor to Republic Aviation Corp.



Storage of liquefied gases (2,682,154). W. Wilkinson, New York, N. Y., assignor to Air Reduction Co.



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Ducted fan and split-compressor turbojet are being developed today. Will tomorrow's engines be nuclear powered? What will they look like?

What Comes AFTER THE TURBOJET?

By **ROBERT W. BONNER**
Chief, Propulsion Section
The Glenn L. Martin Co.

JET PROPULSION was foreshadowed in 1938 when a five year plan for the development of a gas turbine engine was implemented at Wright Field with the letting of preliminary contracts to General Electric and Allis-Chalmers. The following year saw the beginning of the British program with contracts let to Power Jets, Ltd. for the design and construction of the W-1, a jet engine for installation in the Gloster Model E-28/39 airplane. In 1940, the Italian Caproni-Campini CC-2 equipped with a modified gas turbine engine, flew from Milan to Rome. Then just before Pearl Harbor, the Germans began service testing their BMW-003 jet engine in the ME-110 and ME-262 fighters.

The first practical jet engine for propelling aircraft had by this time been demonstrated at Cranwell, England, May 15, 1941. The W-1 jet engine built by Thomson-Houston to Commander Whittle's design, was successfully flown on that date in a Gloster fighter piloted by Flight Lieutenant Jerry Sayer. A few months later at Wright Field, jet propulsion came to America with the first flight of the Bell XP-59A powered by two General Electric 1-A turbojets. Fast on the heels of these developments came the Nazis' V-1 buzz-bomb and V-2 rocket.

● ● Jet Propulsion Today

To get a close look at modern jet propulsion, consider the two most

spectacular aircraft to see service in Korea. The dog fights between the MIG 15 and the F-86 Sabre have certainly been a far cry from those of World War I—with the Nieuport and the Spad pitted against the German Fokker.

Assume that the F-86 is powered with an engine that produces 6000 pounds of thrust at 600 miles an hour. This output is equivalent to 9600 horsepower, or approximately two-and-a-half times the power output of the best reciprocating engine. This engine weighs about 0.4 pound per pound of thrust, or 2400 pounds. This power-to-weight ratio is fourfold over reciprocating engine

Fig. 1—Turbojet engine cycle analysis. Effect of compressor pressure ratio and turbine inlet temperature (Sea level, 350 knots).

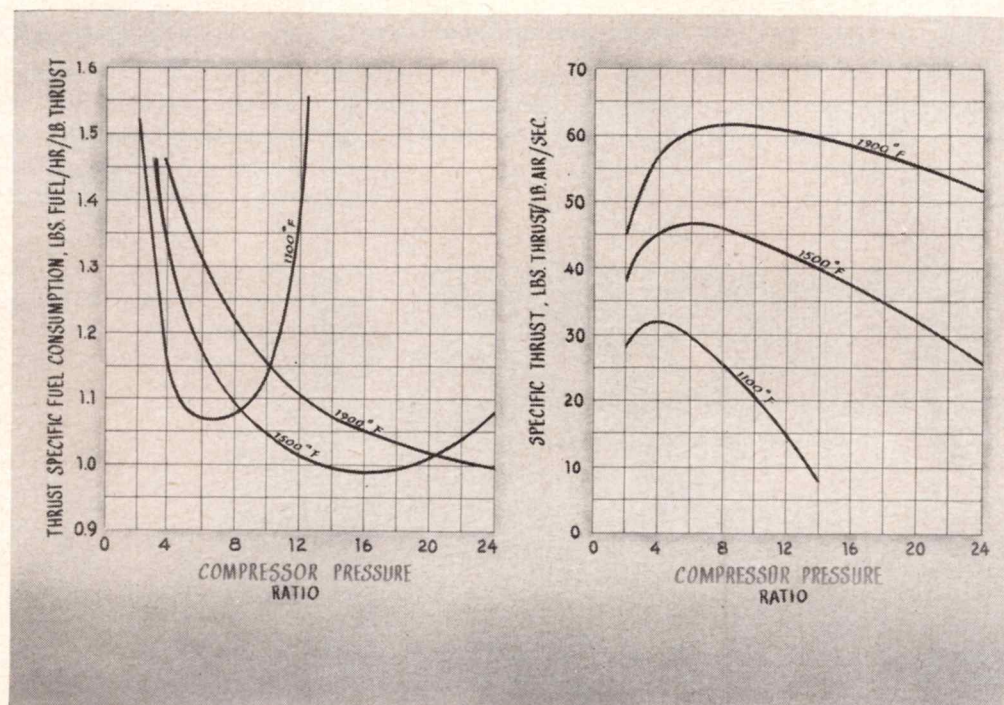
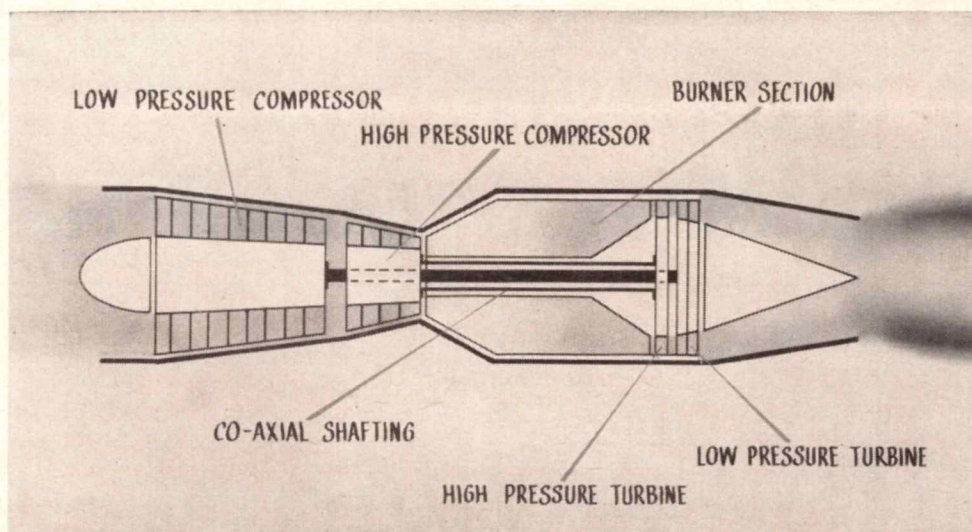


Fig. 2—Twin-spool turbojet engine, typical arrangement.



practice. Specific Fuel Consumption (SFC) is approximately 1.4 pounds per hour per pound of thrust, that is, 8400 pounds per hour. This is equivalent to about 1400 gallons per hour, resulting in a SFC rate of 0.87 pounds per horsepower per hour. The reciprocating engine has a SFC of perhaps 0.7 under these conditions. Thus it is seen that a jet engine produces two-and-a-half times the power of a reciprocating engine for two-thirds the weight and with only three-and-a-half times the fuel flow.

Turbojet economy can be improved by increasing the compressor pressure ratio. Fig. 1 shows a graph giving the variation of SFC with pressure ratio for several values of turbine inlet temperature. There is a very large reduction in fuel consumption as the pressure ratio is increased

from 4 to 1 to around 7 to 1. A decreasing advantage holds for pressure ratios above this value, for turbine temperatures above 1500°F. There is also a reduction in specific thrust, or thrust per pound of airflow, for an increase in pressure ratio.

Because the performance of a turbojet, or of any atmospheric device, is dependent upon its environmental conditions, the variation of SFC with pressure ratio varies from the values shown here, as a function of the speed and altitude in question. However, one can see that economy will certainly dictate larger compressor ratios.

● ● Jet Propulsion Tomorrow

It is time to turn from operational jet propulsive devices to developmental schemes. Ducted fan and

split-compressor or twin-spool turbojets are under development. Ducted fans were studied during World War II by the Germans and the English; and the French have already produced a small ducted fan turbojet. Twin-spool or split-compressor turbojets, with a 50 percent increase in pressure ratio and a 25 percent reduction in SFC, were talked about as early as 1946. Consider this twin-spool or split-compressor engine. In the schematic cutaway of this engine, Fig. 2, it is seen that compression is split into a low pressure and a high pressure compressor, each independently driven by separate turbines. The advantages of this scheme are 1) better efficiency of compression, 2) better acceleration characteristics, and 3) fewer operational compressor problems such as surge or blade stall over the entire speed-

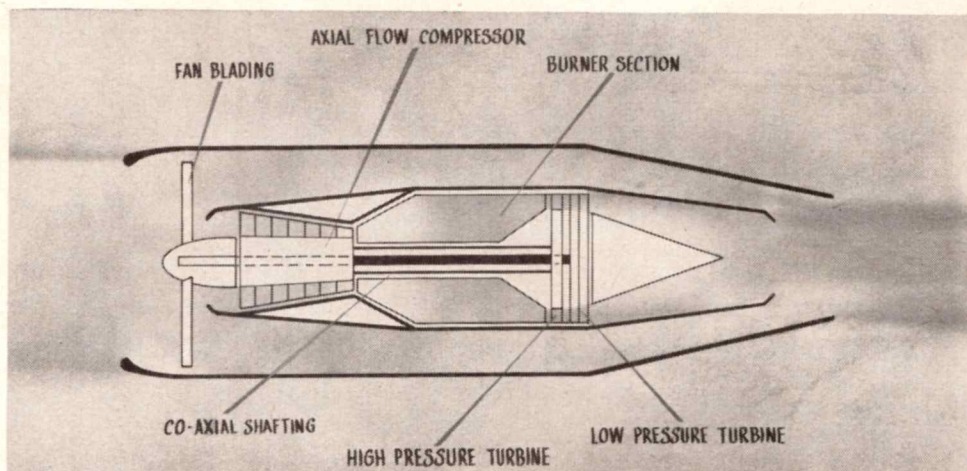


Fig. 3—Twin-spool ducted fan engine, typical arrangement.

altitude operating regime. Engines somewhere in the 10,000 to 15,000 class are being developed, using this split-compressor technique.

Another form of split compressor that might be developed as a by-product of the twin-spool jet, is the ducted fan or turbo-fan shown in Fig. 3. In this engine the air is first compressed by a fan and then by a compressor. After the gas passes through the combustion and expansion processes, it is exhausted through the tailpipe where the gas is mixed, at high temperature and high velocity, with air passed at low velocity and low temperature over the outside of the basic jet engine. This results in a lower temperature, lower velocity jet exhaust. The technique is used to improve the propulsion efficiency, and results in greater economy. In effect, a ducted fan is a jet engine with a shrouded propeller. The shroud serves to collect the air and mix it with the hot exhaust air.

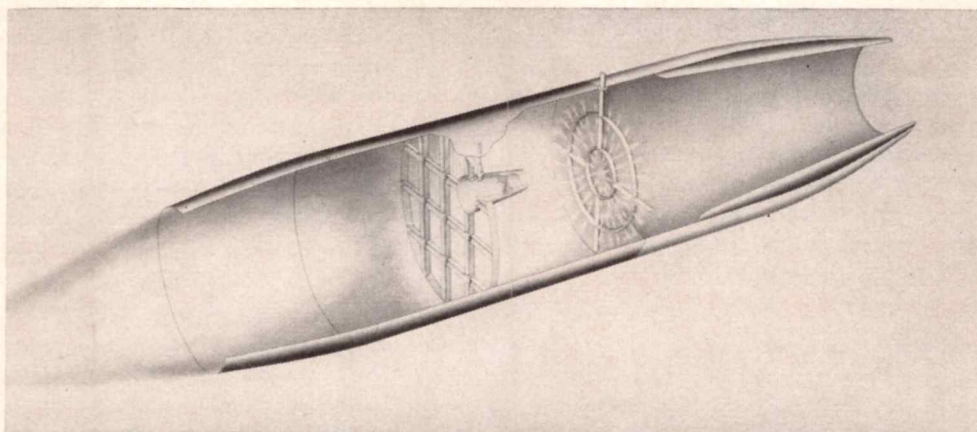
Thus one sees turbojets, single and

engine. This type engine is under development. The fact that compression is by ram or high-speed pressures indicates operation primarily at supersonic speeds. The engine was hailed with enthusiasm at first because of its simplicity. But all designs are simple at birth, becoming complex when reasonably high performance or low economy is to be attained. The ramjet has no static thrust, so that its use in an airplane or missile as a single powerplant is impossible. The device is usually associated with air launching from reciprocating or jet engine aircraft or with a liquid or solid rocket booster, these auxiliary devices being required to enable the vehicle to achieve a speed at which sufficient thrust can be generated for propulsion. This complicates the design and makes the application of the ramjet powerplant more suited to missiles than to fixed-wing piloted aircraft. Certainly, this type engine will have limited application unless more at-

pounds of atomic fuel to surpass the range of any present bomber. But nuclear powerplants are heavy because of the shielding required to prevent radioactive radiations from damaging crew and equipment. Thus the design of an aircraft nuclear powerplant becomes the apparently simple task of designing a unit whose gross weight does not exceed the present powerplant plus the fuel weight of chemically fired engines.

Unfortunately, such a design is not a simple one. Moreover, the facilities required to develop a nuclear powerplant are entirely different from those normally required for jet engine development. The testing must be performed in a secluded area, and personnel must operate and remotely maintain the engine after operation. The cost and time required to develop facilities becomes a major hurdle in the development of an engine. In addition, flight testing of the engine requires new operational techniques which would

Fig. 4—Subsonic ramjet engine, artist's conception.



twin-spool variety, and ducted fans as engines of tomorrow. In order of importance, as a function of speed, the turboprop is used for the slower speed aircraft, then the ducted fan, followed by the double spool and finally the single spool turbojets whose environment is chiefly supersonic flight.

● ● Non-Rotating Engines

The foregoing discussion has been centered around rotating jet propulsion devices. Consider now some of the non-rotating devices. Fig. 4 shows an artist's conception of the ramjet

tractive schemes of self-acceleration can be developed.

● ● Nuclear Propulsion

There is widespread interest in nuclear-powered jet propulsion devices. Despite the apparent availability of gasoline for chemically powered engines, still the amount of fuel used in an all-out emergency would be staggering. Moreover, the all-up or take-off weight of modern bombers is enormous because of the high gasoline load. Even an inefficient nuclear reactor would provide a bomber with enough power from a few

avoid overexposure of maintenance personnel to radioactive radiations. For example, one might find it impossible to service the aircraft or even permit the flight crew to emerge from the shielded crew compartment for many hours after landing.

By-passing the operational problems, look at some engineering problems. Fig. 5 shows a schematic diagram of a submarine nuclear powerplant. The two reactors being built are called the STR, *Submarine Thermal Reactor*, with water coolant; and SIR, *Submarine Intermediate Reactor*, with sodium coolant. The

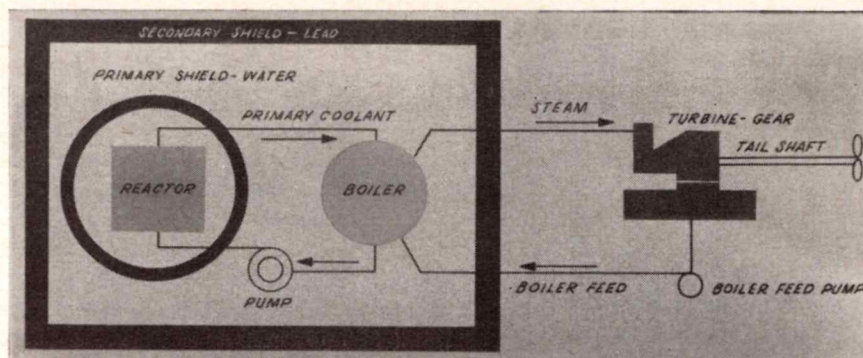


Fig. 5—Schematic diagram of a submarine nuclear powerplant.

primary difference between these two powerplants is the speed of the neutrons during fission, the thermal being the slower of the two. In both types, the water or sodium is pumped through the reactor and delivers its heat to the steam boiler. The conversion to shaft horsepower is then made through a conventional steam turbine. The scheme shown here utilizes a split shield, that is, primary and secondary, to minimize radiation. The secondary shield is required to protect personnel from dangerous gamma rays contained in the primary coolant after its passage through the reactor.

When the engineer considers the application of these cycles to aircraft propulsion he is momentarily discouraged by the apparent weight penalties of a high pressure water system and by the dangers of handling liquid metals throughout an

airborne vehicle. However, a solution suggests itself: simply replace the combustion chamber of a turbojet with a nuclear reactor and use air as the primary coolant. However, the radiation problems are not minimized; at this date one wonders how soon a sufficiently lightweight nuclear powerplant can be built.

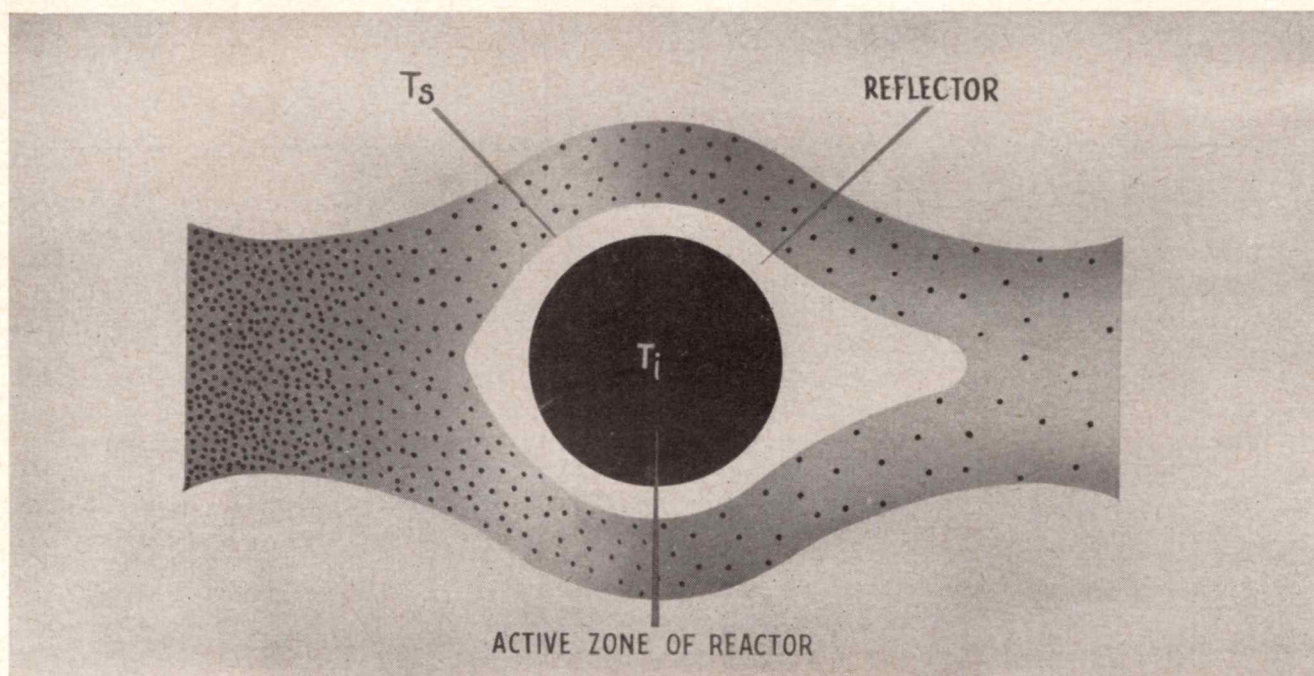
Some work has been done. Fig. 6 shows a hypothetical nuclear powered ramjet. In this case the air is heated by radiation. Small heat-absorbing particles are admitted to the air stream before entry into the engine. Heat radiated from the center reactor is transferred to the particles, and hence to the air, for propulsion. Unfortunately, this scheme is not feasible because insufficient heat is transferred by radiation at present operating temperatures. Conduction and convection methods of heat transfer are required for rapid

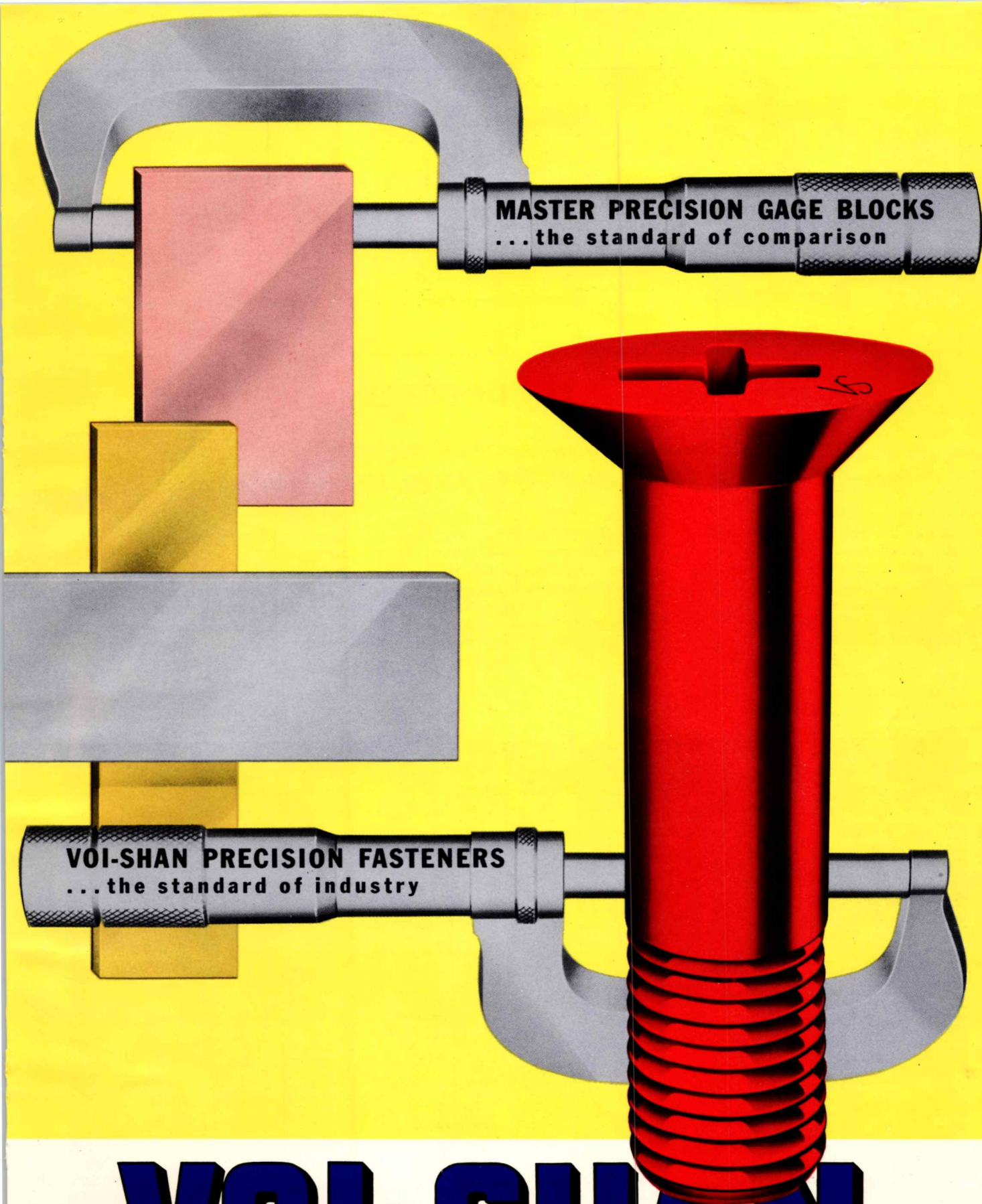
heat absorption; this can be effected only if operating temperatures are considerably above those imposed by present metallurgical limits.

A futuristic look at powerplants shows propulsion by expulsion of high velocity ions or electrical particles, and also by expulsion of photons of light. In the ionic powerplant, electrical potential would be directly converted into accelerated particles, that is, there would be an electrostatic acceleration of ions.

The immediate future will perhaps see turboprop powerplants in most commercial flight, ducted fans for subsonic military use, where economy is required; and single or split turbojet engines, together with ramjets, for supersonic flight. Liquid rockets will take their place as military weapons, and nuclear powerplants will eventually power ground and airborne vehicles. END

Fig. 6—Hypothetical nuclear powered ramjet.





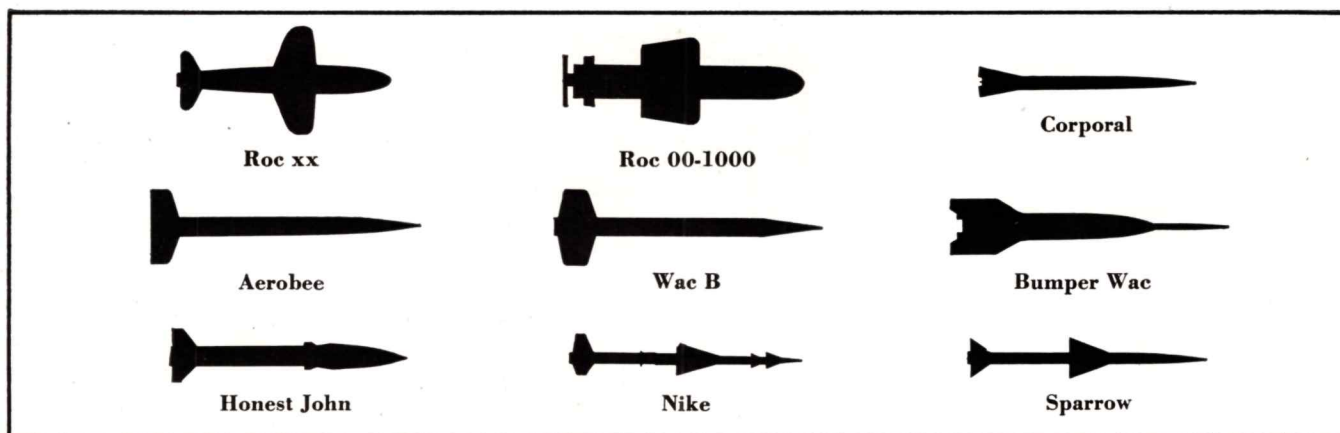
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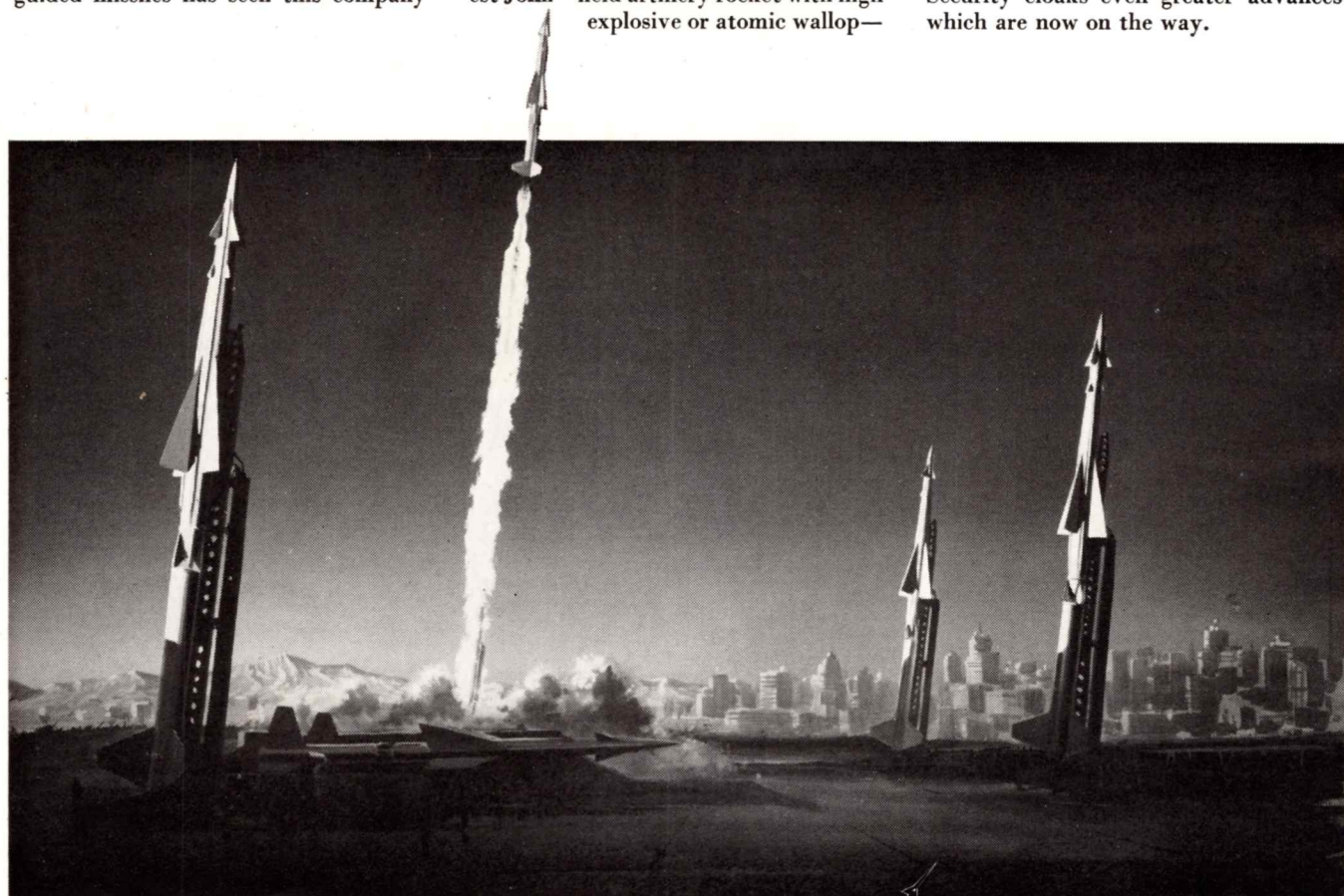
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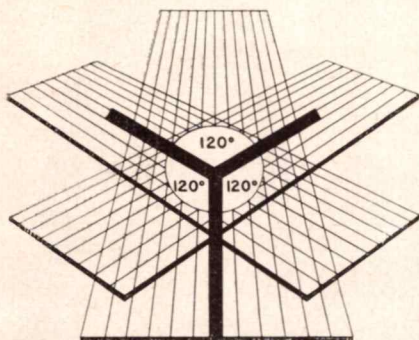


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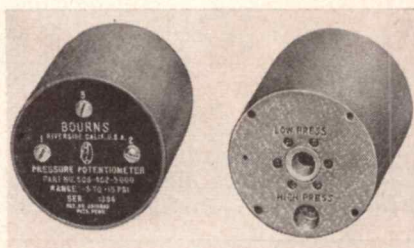
● Glass Reinforced Plastic Sheet

A moldable, high-strength plastic sheeting sold as "Scotchply" was announced recently. New material is a glass-in-plastic laminate designed for mass production of reinforced plastic parts and structural members. It consists of one or more uncured moldable sheets of plastic, each integrally reinforced with lineally aligned continuous glass filaments. Each sheet is composed of 60 percent glass and 40 percent plastic resin by weight. Three forms of the new material are available. Where exceptionally great strength is desired in only one direction, all filaments are oriented in that direction in each ply of the laminate. Where a strength relationship is required in two directions, a lamination can be supplied where the filaments run in the two desired angles. Where equal strength is desired in all directions, sheets of the material are laminated together at 120 deg. angles to produce an "isotropic laminate"; when processed and hardened, this form has equal strength in all directions in the laminating plane. The plastic may be readily formed, and hardened or cured by heat and light pressure.

Properties include: tensile strength 41,000 psi; flexure strength 64,500 psi; compressive strength 42,000 psi; heat distortion at 264 psi, 350 deg. F.; dielectric strength 700 volts per mil. Minnesota Mining and Manufacturing Co., 900 Fauquier St., St. Paul 6, Minn.

● Miniature Self-Locking Nuts

Engineered in conjunction with standards engineers of Hughes Aircraft to meet demands of the electronics industry in its miniaturization program, the Kaylock miniature nut utilizes a simple positive principle wherein the upper threads are made elliptical and highly resilient, allowing all threads to carry the actual load thus eliminating the necessity of an auxiliary locking device. According to manufacturer, there is no danger of fungi accumulating in terminals in electronic applications and nut can be used in temperature ranges up to 550°F. The nuts are now produced in a range of sizes in three basic configurations: two lug, one lug and corner types. The Kaynar Co., Kaylock Div., 820 E. 16th St., Los Angeles, Calif.



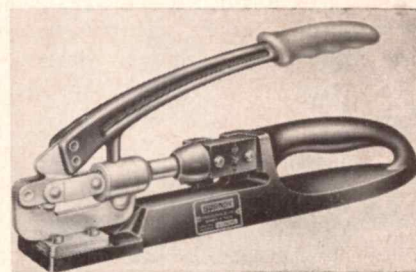
● Differential Pressure Potentiometer

Engineered to withstand usage encountered in missile and rocket applications, Bourns Model 508 differential pressure potentiometer measures the difference between pressures applied to two pressure ports. Typical applications are the measurement of fuel tank pressure, airspeed and pressure drop across an orifice. Performance characteristics include resolution of 0.025 percent to 0.50 percent for resistances from 1000 to 10,000 ohms. Optimum linearity and repeatability with minimum hysteresis are claimed through use of a specially developed beryllium copper diaphragm type bellows. Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.



● Test Chamber

A Conrad climatic test chamber with full instrumentation and temperature range has been developed as a compact portable unit, small enough to be rolled through standard doors so that on-the-spot tests can be made as desired. The chamber has from one to four cubic feet of test area, and a temperature range of +300 to -100°F. Wider ranges are available and humidity features can be added. The chamber uses the Freon 13 and 22 Cascade system. Features are: all metal construction; oven baked enamel exterior; rigid type, vapor proof insulation; stainless steel interior. Conrad Inc., Holland, Mich.



● Toggle-Action Hytool

The Y10Q-1 Hytool, for installation of compression-type lugs, links and ferrules, may be portable or bench-mounted. It features a toggle-action with high mechanical advantage, providing one hand operation. The body is cast from malleable iron, and the handle is a rigid one piece duc-

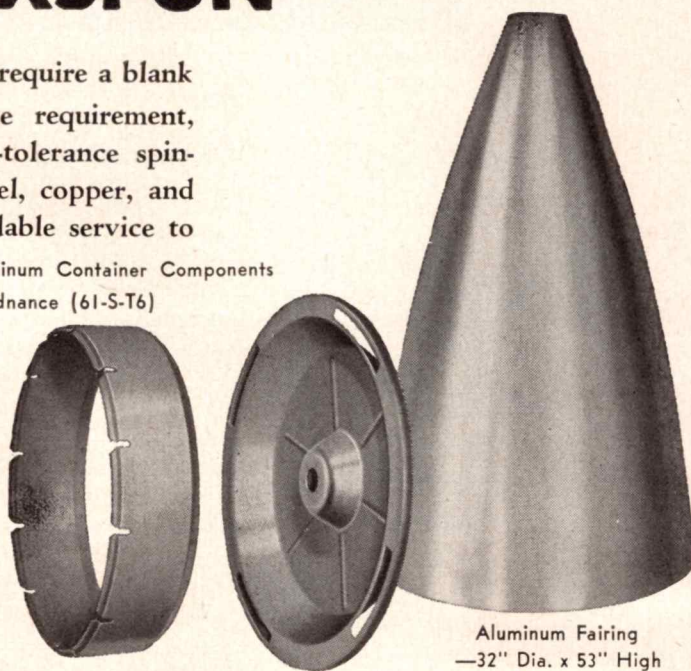
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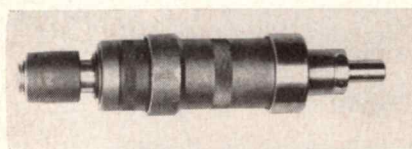
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tile iron casting. Interchangeable dies accommodate complete range of Burndy Hyrings for shielded and coaxial cables, and all Hylugs and Hylinks for copper aircraft wire sizes #22 through #10. Burndy Engineering Co., Inc., Norwalk, Conn.



• Torque Wrench

Operating first as a nut runner, Pow-OR-Tork runs the fastener down, functions as a true torque wrench until the fastener reaches a pre-determined torque, and then automatically releases. Pow-OR-Tork

is available in mechanically supported single- and multi-spindle wrenches and to any bolt pattern. Sizes range from those suitable for instrument assembly, to the largest industrial installations. Operation, which is silent, can be designed for air power, standard 60 cycle or high cycle use, with magnetic or air differential release. With air differential release, the torque may be remotely controlled. Ohlsson & Rice, Inc., 3340 Emery St., Los Angeles, Calif.

• Multiple Inspection

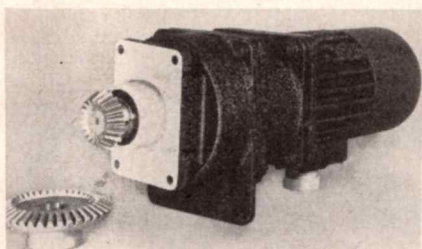
Sheffield's Plunjet gaging cartridges are the size-sensing elements on the Precisionaire gage used to inspect three outside diameters and two flange thicknesses simultaneously on a cylinder. Operator places part on serrated worktable and slides part

forward into gaging position. Five dimensions are checked and floats in the five air columns indicate which dimensions are within tolerance or the amount they are oversize or undersize. The gaging cartridge is approximately $\frac{3}{8}$ " in diameter by $1\frac{1}{2}$ " long. Plunjets are available for inspecting parts with tolerances ranging from 0.0001" to 0.100". The Sheffield Corp., Dayton 1, Ohio.

• Self-Sticking Tapes

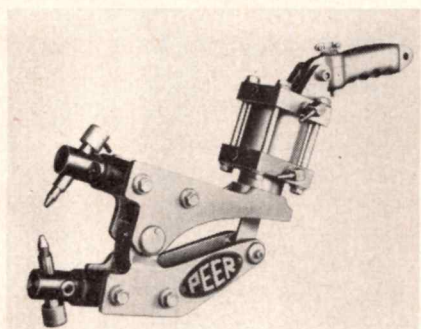
Two new Permacel pressure sensitive printable cotton cloth tapes are now available. The self sticking tapes meet requirements of JAN-P-127, Tape II, Grade B. Permacel 641 production grade and Permacel 651 medium strength can be used to hold cold rivets prior to being set, hold insulation on pipe lines and hold

loose or movable parts on machines and equipment. They can be used in packaging for sealing lids on fiber board, metal drums, tubes and canisters, closing seams in corrugated cartons, sealing tops of liner bags and heavy industrial paper bags. Having an average adhesion of 45 oz./in., a 10 percent elongation, a 14 mils thickness and a tensile strength of 37 psi and 50 psi, respectively, P641 and P651 have additional applications such as protecting finished (non-painted) surfaces against abrasion or corrosion in shipment or in manufacturing, protecting threaded pipe ends, and cutting surfaces of tools. The Permacel Tape Corp., New Brunswick, N. J.



● Rotary Actuator

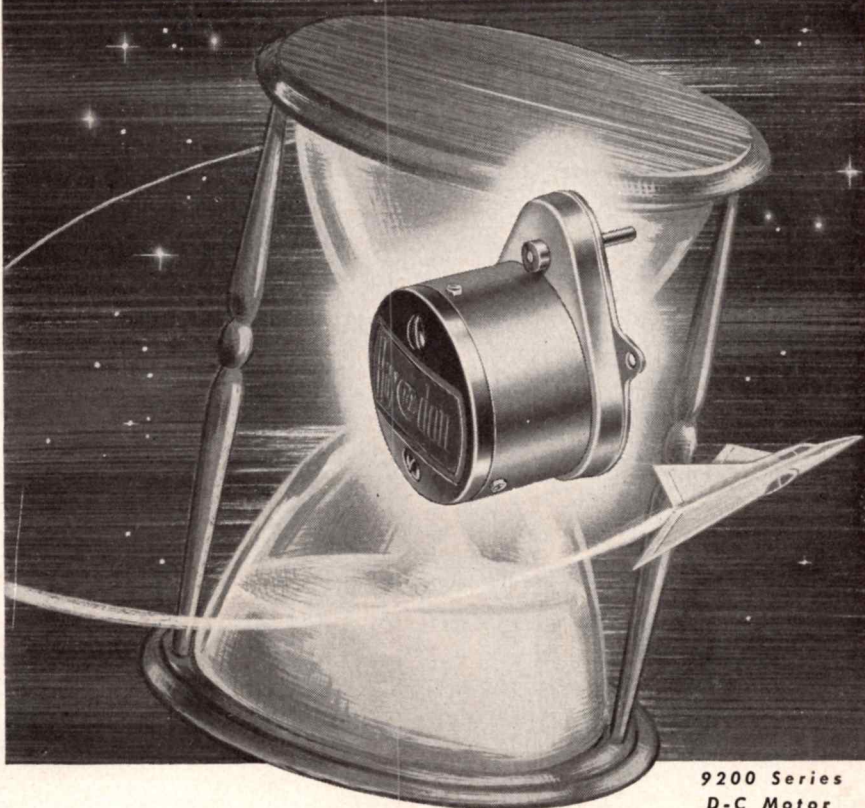
A new rotary actuator by Western Gear Works is a 7/10 horsepower unit, 200-v., 400 cycle, 3 phase. Locked rotor torque is 12 lbs. with 11,200 rpm input and 38 rpm output, 7 amps. continuous duty. It can be rotated 330 deg. (plus or minus 2 deg.) in either direction. Western Gear Works, P. O. Box 182, Lynwood, Calif.



● Portable Gun Welders

A new line of Peer lightweight, heavy-duty portable gun welders speeds production on large sheet metal and wire assemblies. The gun welder units are available in 30 to 100 KVA capacities for either air or

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TIMING — a vital factor to consider if you design or build military aircraft or components! So, HAYDON constantly applies its facilities, skills, and talents to find solutions for aero-timing problems. For d-c: Small, compact motors to control timing devices with complete dependability . . . helping airmen chart the course of time! Built to Military specifications, the HAYDON 9200 Series can be calibrated for 6-30 volts. For 28 volts, the 9250 Series may be your answer — RF filtering available. HAYDON d-c timers using these motors, are available also.

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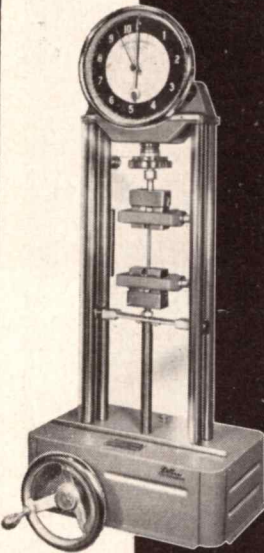
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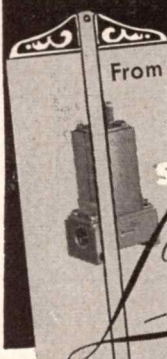
Precision Dillon Tester may be used in **TENSILE, COMPRESSION, TRANSVERSE or SHEAR** testing with equal accuracy. Hand operated or motorized, will test any type material in flats, rounds or special shapes. Seven capacities from 0-250 lbs. up to 0-10,000 lbs. Fully portable. Has self-aligning grips, maximum hand, ball bearings. America's most popular low priced tester! 6 to 8 DAY DELIVERY. Write today for illustrated brochure.

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New ruggedness at ½ the weight
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New dependability at ½ the weight.
Yet the same flow capacity as the V-200-12A.

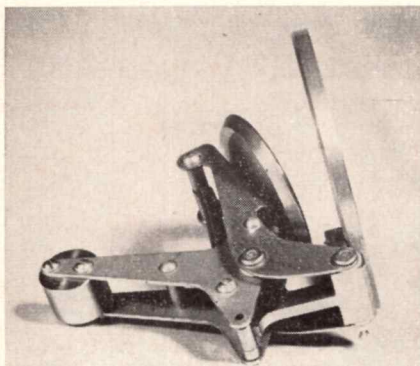
This remarkable achievement means a greater freedom of design for the engineer than ever before. The VALCOR V-3900 is setting new standards of Solenoid Valve performance where low pressure drop and lightweight are a factor.

Pat. Pend.

VALCOR
SOLENOID VALVES

VALCOR ENGINEERING CORP., CARNEGIE AVE., KENILWORTH, N. J.

air-hydraulic operation on 220-, 440- or 550-v. power supplies. Six basic gun types are available for special applications. Associated operating equipment includes: water-cooled flexible cables, overhead suspended transformer with balancing arm, timing and contactor controls. Optional features include: ball bearing suspension, extra long or retractable stroke, spring balance for maximum vertical movements, special jaws and electrodes. Peer Inc., Benton Harbor, Mich.



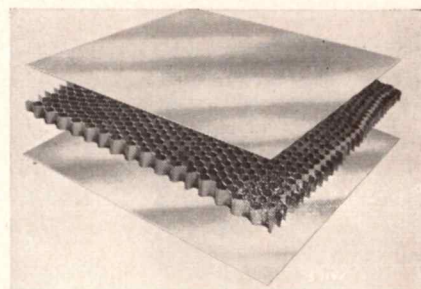
● Flapper Valve with Latch

Aero Supply has developed new

type valves that act as flappers only when their action is needed, during flight maneuvers of the aircraft and when forces would cause undesirable movement of fuel in tanks. During level movement of the aircraft on the ground or under other preselected conditions, the valves remain locked in the open position, and permit unrestricted flow in both directions. Tanks can be fueled at the downstream side of valves without danger that the valve will be sucked closed. Aero Supply Mfg. Co., Inc., Corry, Pa.

● Selenium Rectifier Kits

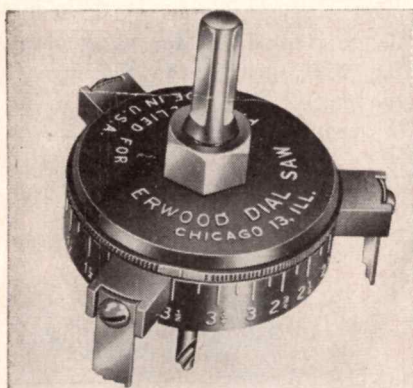
A series of seven vacuum processed selenium rectifier kits saves time for development engineers. The kits contain assembled rectifiers marked with commercial coding. They offer a range from 3/16 inch diameter plates to 5 inch by 6 inch plates, with ratings from 1.5 ma DC up to 3700 volts peak inverse to types rated at 10 amp. and 220 volts. Bradley Laboratories, Inc., New Haven, Conn.



● Cellular Stainless Structures

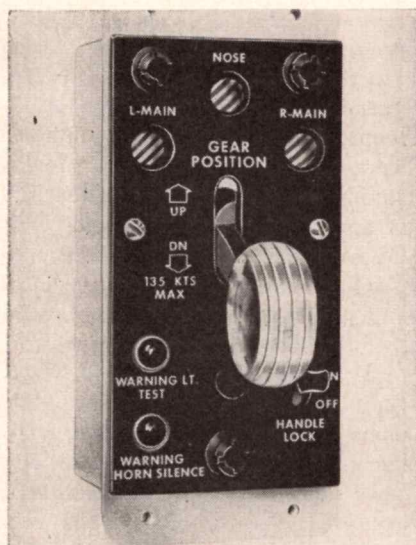
A cellular stainless steel mat fabricated from Armco 17-7 PH stainless strip, has a honeycomb filler sandwiched between two stainless steel sheets. The 0.002" to 0.003" thick honeycomb wall material is bonded into panels with adhesives or by brazing. This permits the skins or panel faces to be stressed to their yield strength. The core carries the shear and compressive loads and stabilizes the faces, thus preventing premature buckling. This precipitation-hardening stainless steel develops typical tensile yield strengths of 180,000 psi, and higher compressive strengths, through double low-temperature heat treatment. Cellular

panels from 17-7 PH are being considered for jets, rockets and missiles at temperatures up to 900°F. Manufacturer says they can be used in cold and hot service for tail pipe shrouding, leading edge sections, bulkheads, fins, control surfaces, afterburner cases and other applications demanding corrosion resistance with lightness and enduring strength. Product Information Service, Armco Steel Corp., Middletown, O.



● Dial Saw

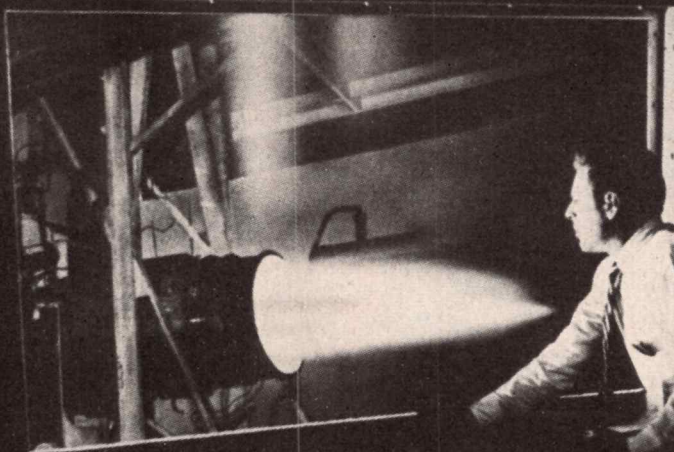
Erwood's dial saw No. 400 cuts holes from 1 1/8" to 3 1/2" in diameter in most materials. Saw is complete with pilot drill and three sets of cutting blades; one set for steels for 3/8" depth, one set for non-ferrous metals and plastics, and one set for wood. Erwood, Inc., 1770 Ber-teau Ave., Chicago 13, Ill.



● Landing Gear Control Panel

Avionic Model A401 is a composite landing gear control panel de-

How Much Thrust In A Sheepskin?



Although the learning and technical "know-how" behind a diploma may provide the initial power for a take-off into the competitive engineering world of today, they can soon be outweighed by the *drag* of uninspiring and routine tasks. The *thrust* of education, even when combined with ambition and ability, will not reach its potential height on the ladder of achievement without the aid of modern testing facilities and "tools of the trade" . . . wind tunnels, electronic computing devices, propulsion, microwave, physical test and research laboratories.

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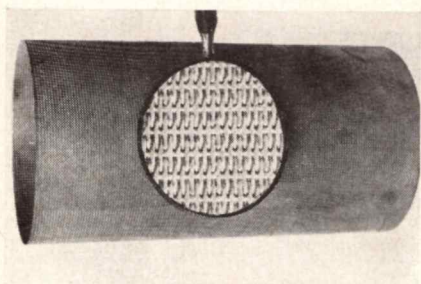
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signed for instrument panel mounting forward of the power quadrant. It measures 3½" wide by 6" high by 2" deep, and contains all controls and indicators. Features are: wheel-shaped knob contains red warning light which causes active knob to glow, indicating unsafe condition or that landing gear is not consistent with handle position. Push button to test condition of warning light bulb is on face of panel. Solenoid operated positive lock holds handle in down position when aircraft is on the ground, and automatically releases when aircraft is airborne, allowing handle to be raised. Emergency ground retraction is possible by means of solenoid lock over-ride button on face of panel beside lever. Three type C-1 position indicators show position of individual gear. A push button silences warning horn when flight conditions require it. Placard on panel tells pilot safe air-speed for lowering gear. Unit contains all switches for directional control of landing gear actuator or hydraulic valves and for sequencing of warning signals. Entire front panel internally lighted and all electrical connections are made at rear of panel. Avionic Products Engineering Corp., Dover, N. J.

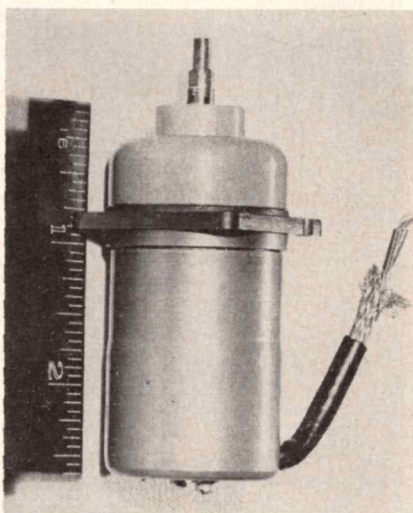


● New Cooling Medium

Rigimesh is intended for use in transpiration cooling of afterburner liners, ram jet combustion chambers, gas turbine control plugs, turbine blades, and so forth. The medium is made by welding together the warp and woof strands of one or more layers of woven wire cloth, and then mechanically treating them to produce a homogeneous plate having finer openings but with the uniformity of the starting material. Flow capacity for coolant gases and liquids can be varied from 15 fps at 1 psi differential pressure, to 0.2 fps. at 1 psi.

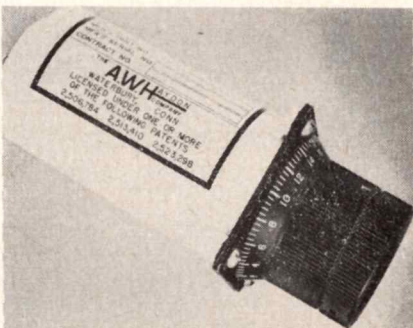
For some permeabilities, room

temperature tensile strengths exceed 60,000 psi. According to the manufacturer, Rigimesh materials at elevated temperatures retain a higher proportion of their room temperature mechanical properties than do porous metals fabricated from powders. To obtain the degree of heat transfer required, thickness may be varied from 0.005" to 0.125". Aircraft Porous Media, Inc., Glen Cove, N. Y.



● Permanent Magnet Motor

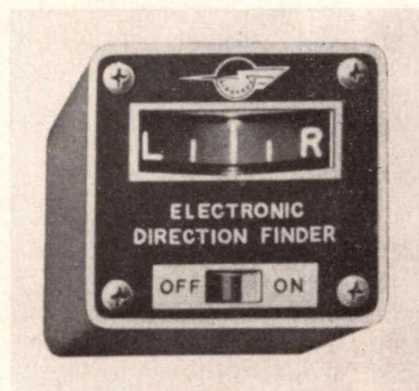
A miniature permanent magnet motor is in production for use in high speed aircraft and guided missiles. Weighing 3¾ ounces, and being 2" in over-all length, the motor is so designed that modifications of speed, torque and other performance characteristics can be made to make it producible for a variety of uses. Motor is equipped with a miniature gear train accomplishing gear reductions as high as 1600 to 1. Airquipment Co., Inc., 2248 E. 37th St., Los Angeles, Calif.



● Time Delay Relay

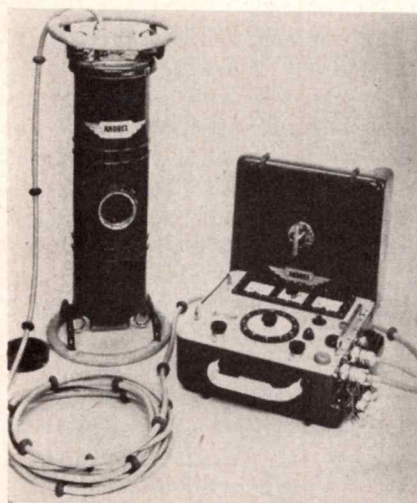
A new line of Haydon precision adjustable time delay relays for mili-

tary applications has been announced. The timers are supplied in a 2.2" diameter aluminum housing, 4¼" long. Weight of unit about 1¼ lbs. A calibrated dial with positive detent makes rapid and accurate adjustment easy. Accuracy is 1 percent, and one model (adjustable from 2 to 30 seconds), is calibrated in 0.2-second increments. The unit, for use on 24 to 29-v., dc, features the Haydon 5600 Series chronometrically-governed motor. Standard electrical connection is to screw terminals, but solder type can also be supplied. A flange is provided for panel mounting with the dial on the front of the panel. The A. W. Haydon Co., Waterbury, Conn.



● Electronic Direction Finder

Aerotron Model 367 "EDF", low cost lightweight radio compass type direction finder, designed specifically for private aircraft, operates in conjunction with standard low-frequency receiver, and (except for loop) is completely self-contained. To operate, pilot tunes any desired station on the receiver and the EDF is turned on by means of an OFF-ON switch on face of instrument. Indicator immediately becomes active and points either to zero indicating that the station is directly ahead, or to L or R if the station is left or right of the plane's course. As the plane drifts off course, the EDF, through the receiver, emits a 400-cycle pitch tone as an indication to the pilot. Instrument weighs only three pounds, fits in any standard 2¼-inch mount, and is easily installed. Reliability is not affected by altitudes or mountainous terrain. Air Associates, Inc., Teterboro, N. J.



● Portable X-Ray Unit

New 160 kVp portable X-ray unit for industrial radiography is now available. It is lightweight and capable of X-raying steel 2" thick. Components are a tube unit (120 lb.), a control unit (60 lb.), and lightweight connection and power cables. The unit operates on 110 and 220 volts independent of separate transformers. Focal spot in the centrally located X-ray tube is 1.5 mm, to insure sharp definition in radiographs. Holger Andreasen, Inc., 703 Market St., San Francisco 3, Calif.

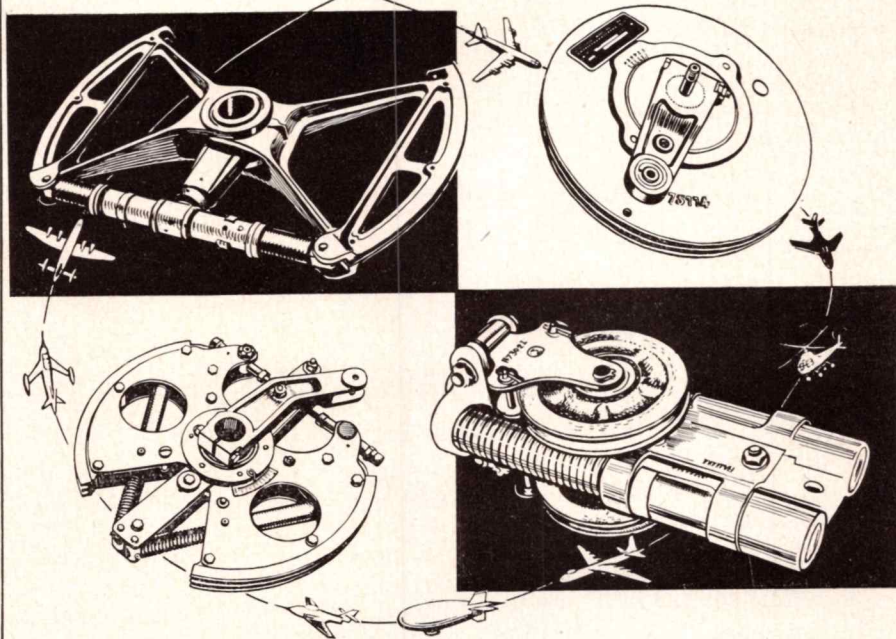


● Rubber Miniature Custom Parts

By means of injection molding, custom molded rubber parts having complex structure can be produced in miniature with dimensional tolerances as close to ± 0.001 in. Industrial uses of the parts are found in

standard or custom...

Pacific CABLE TENSION REGULATORS give maximum FLEXIBILITY



**... for positive control cable action — on all types of aircraft — at all times!
Eliminate cable slack or stress under any temperature or flight condition!**

FLEXIBLE OPERATION — Pacific Regulators, designed by Sturgess, *automatically* compensate for normal airframe flexure and temperature changes which can greatly affect cable tension. Cables can be rigged at lower tensions to reduce friction and wear. Controlled cable tension is inherent in a Pacific regulated system.

FLEXIBLE APPLICATION — for all types of military planes — bombers, fighters, transports, helicopters, and lighter-than-air, as well as commercial and private planes. Pacific Regulators have been solving the problem of tension regulation on all types of aircraft for over 10 years.

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EASTERN REPRESENTATIVES: Aero Engineering, Inc., 288 Old Country Road, Mineola, L. I., New York • 2510 St. Paul St., Baltimore, Md. • 20 North Meridian St., Indianapolis, Ind. • Aero Sales Engineering, Billingsbridge, Ottawa, Ontario

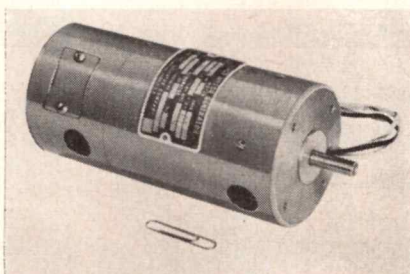
LOS ANGELES, CALIF.
1430 Grande Vista Avenue

SAN FRANCISCO, CALIF.
25 Stillman Street

SEATTLE, WASHINGTON
421 Michigan Street

ARLINGTON, TEXAS
111 East Main Street

spraying valve seals, relief valves, and hydraulic seals. Manufacturer claims that the molding process permits greater quality control by eliminating "flash" found in compression molding and also secondary operations such as hand and machine trimming. Many compounds of Neoprene, Buna N and Silicone synthetic rubbers can be injection molded for these applications. Minnesota Rubber & Gasket Co., Dep't KP, 3630 Wooddale Ave., Minneapolis 16, Minn.



● Motor-Tachometer Combinations

A new line of Elinco dc motor and dc tachometer combinations features

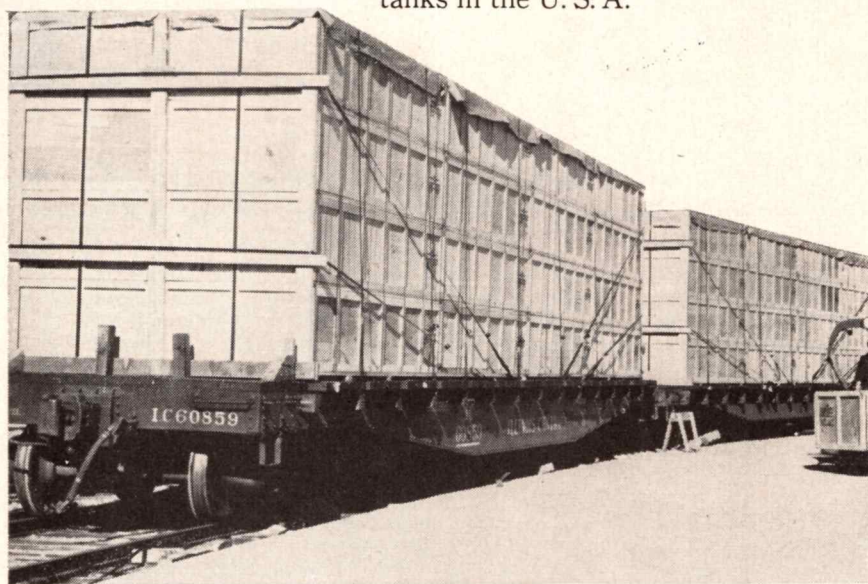
high performance with compactness. Units measure $2\frac{3}{8}$ " in diameter by up to $5\frac{1}{2}$ " in length. All combinations supplied with auto-reset thermal overload protectors, with capacitor filters for both motor and generator optionally available. Line includes units with standard motor outputs of 5 to 100 watts for speeds to 10,000 rpm, with operating voltage range from 6 to 220 volts. Standard tachometer output: 6 volts per 1000 rpm ± 10 percent. Linearity of all units within ± 1 percent; maximum ripple, 4 percent or less, without filtering. Electric Indicator Co., Inc., Springdale, Conn.

"TOO LATE" is a horrible term in war.

Fletcher's on-time, ahead-of-time record, in fulfilling of contracts when due, is unsurpassed.

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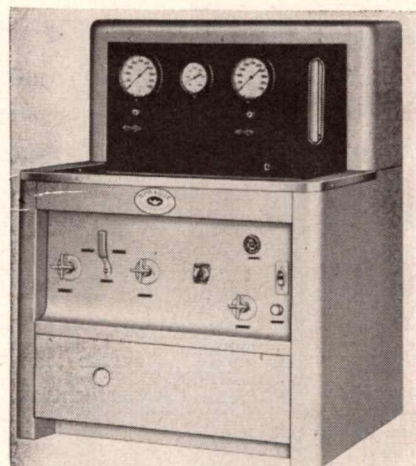


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● Hydraulic Test Bench

A low-cost hydraulic test stand, Sprague Model S-1000-603 operates at pressures to 3000 psi and flows to 6 gpm. The stand retains design features found in larger Sprague units. Unit is self-contained in a heavy-gage, all-steel welded cabinet, and is equipped with necessary instrumentation and controls including flow control valve, flowmeter and oil cooling circuit. Features are: controls out in front, no need to reach around work in progress. "Toe-under" front base panel allows greater comfort, reduces scuffing. Pressure outlets located at forward part of tray, pointing in, away from operator. Sprague Engineering Corp., Gardena, Calif.

CORRECTION

The correct spelling of the name of the author of "Simplified Performance Prediction" in the December 1954 issue is Ken S. Coward.

HOW TO "SWEEP" A MISSILE

Minute bits of metal that wedge in out-of-the-way places in the Chance Vought guided missile *Regulus* during assembly are removed in a unique "roll-over" jig that permits rotating the missile shell. The small pieces collect in corners where vacuum cleaning will not remove them.

Before the engine is installed in the cigar-shaped *Regulus*, two rotation rings are mounted on the nose and tail sections. A small power drill motor turns the missile slowly in the jig. The bits of metal drop from their corners and are collected, about a handful being shaken loose from each unfinished missile.

Technicians are working on a vibration machine for installation inside the missile shell which will further assist in dislodging the metal particles. END

ONE MAN HELICOPTER

UNCLE SAM'S combat forces may soon do their hedgehopping by air as a result of the development by Goodyear Aircraft Corporation of a one-man helicopter.

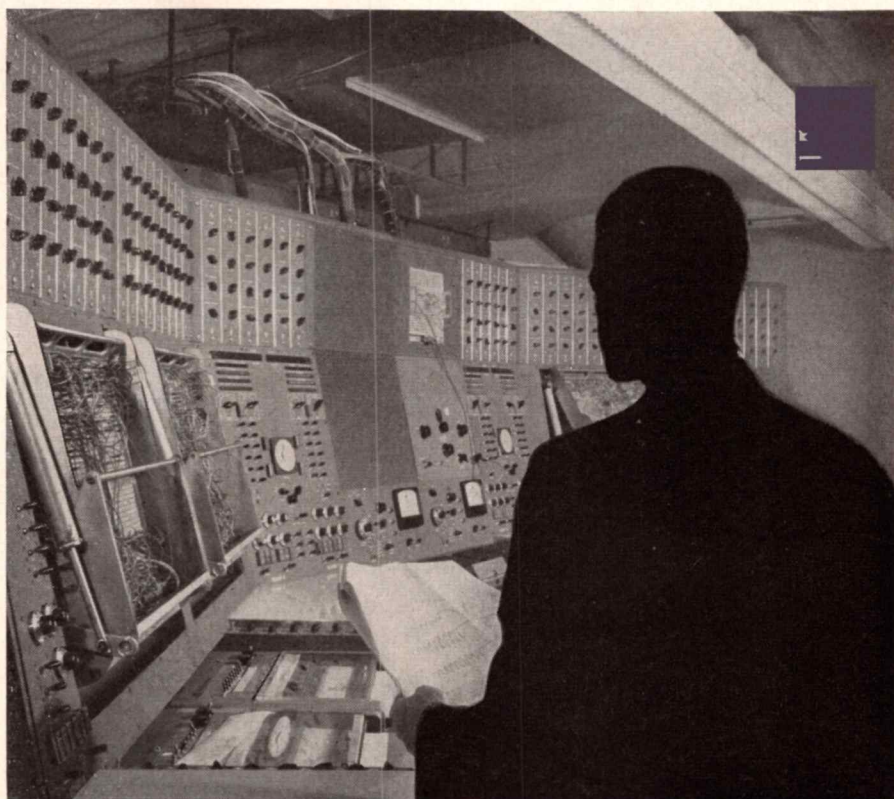
The craft, the GA-400R, is designed to serve as either a courier-liaison or tactical vehicle. The prototype model is being demonstrated to interested military agencies.

Designed primarily for any tactical purpose requiring transportation of one man at speeds up to 60 knots, the GA-400R is said to be economical to produce and to have low maintenance requirements.

• • Detail Design

An airframe of welded tubing is supported by steel out-rigger tubes on the alighting gear of parallel aluminum skids. Power is supplied by a production, water-cooled, two-cycle engine driving rotors through a belt and pulley arrangement.

TO THE FINE ENGINEERING MIND
SEEKING THE CHALLENGING PROJECTS IN



DYNAMICS

Convair, in beautiful San Diego, California, now offers exceptional career opportunities to **DYNAMICS ENGINEERS** with experience in: general flight and control dynamics for both airplane and missile design — analysis and synthesis of servomechanisms, autopilot design, controls and computers — aeroelasticity, fluid dynamics, vibration and flutter — aerodynamic, dynamic, and transient load analysis — solution of dynamic problems by analytical methods and by analog machine computations. Special opportunities for men holding advanced engineering, physics, or mathematics degrees.

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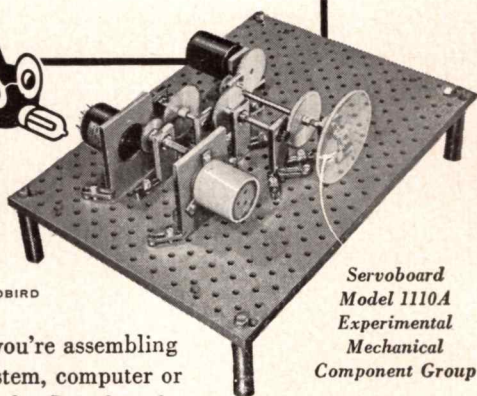
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The GA-400R is capable of hovering maneuvers, pattern flight, steep turns, high speed forward flight, and rolling pullouts. END

PLASTIC AIRPLANE

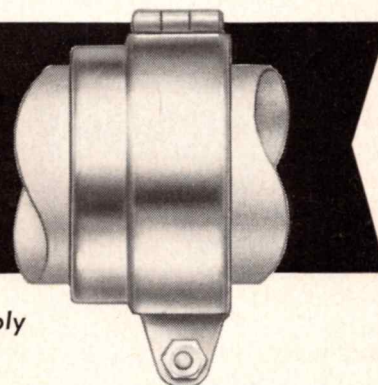
Taylorcraft, Inc., of Conway, Pa., has recently announced that production models of an airplane with an exterior almost completely made of reinforced plastics are on their assembly line. The plane is the first step of Taylorcraft's long-term engineering studies in the use of new materials for light aircraft. In addition to the fuselage and wings, the plane's seats, doors, gas tanks, wheel pants, cowl, instrument panel, and other parts are made with glass-reinforced plastics. Of the exterior surfaces, only the rudder and elevator, because of flight characteristics, are covered with fabric. Altogether, about 60 pieces of this material are used to make 15 secondary structural units.

To aid in constructing the plane, plaster molds are made of the fuselage, wings, and other sections. Glass cloth and resin are placed in the mold and permitted to cure. The parts are then riveted or otherwise attached to the tubular steel skeleton of the fuselage and the spruce and aluminum wing structure.

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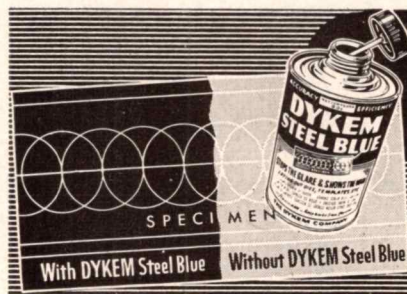
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TRADE LITERATURE AND PAMPHLETS

• Arc Welding Data

A new series of catalogs designed to help welding engineers and others concerned with production and maintenance welding, describes the line of Murex electrodes for arc welding as well as rods and wire for gas, submerged arc and inert arc. Specific catalogs cover electrodes for mild steel and low alloy, coil wire for submerged arc welding, stainless steel electrodes and bare wire, aluminum and phosphor bronze electrodes and bare wire, aluminum electrodes and bare wire, electrodes for cast iron, gas welding rods and tungsten rods. Each catalog lists physical properties, chemical analyses, qualifications, procedures, sizes and general engineering data. Metal & Thermit Corp., 100 E. 42nd St., New York 17, N. Y.

• Insulation Sleeving

New aircraft specification grade Vinyl insulation sleeving conforming to Spec. MIL-I-7444A(1), Resinite EP-93, features low-temperature flexibility to -90 deg. F combined with fungus resistance, full flame resistance in all sizes, and a dielectric strength averaging more than 500

volts per mil in 0.020" wall thickness. Resin Industries, P.O. Box 1589, Santa Barbara, Calif.

• Hufford Machines at Work

New booklet contains photographs illustrating Hufford stretch-wrap forming machines. Material presented in eight general categories illustrating stretch-wrap formation of sheet materials, integrally stiffened skins, milled skins, extrusions and similar formed sections, and of special materials such as stainless steel and titanium. Several pages of forming techniques and typical tooling are also included. Hufford Machine Works, El Segundo, Calif.

• Screw-Lock Inserts

Bulletin 715-A issued by Heli-Coil contains selection tables, drawings showing installation, and instructions on use of new screw-lock insert. Conforming to the quality specifications of the standard stainless steel insert, the new insert has the feature of a constricting grip-coil at the bottom of the insert. A force is produced which holds the screw or stud and eliminates the need for lock-washers, lock-nuts and lock wires. The insert

meets prevailing torque requirements specified in AN-N-5b and similar governmental specifications for high temperature applications. The docked screw or stud may be freed by applying breakaway torque equal to the torque applied in making the original assembly. Available now in four sizes: 6-32; 8-32, 10-32, and 1/4-28. Heli-Coil Corp., Danbury, Conn.

• United Controls

A series of technical bulletins, tabbed for easy reference filing, describe new products of United Control Corp. Bulletin 401 relates to the components of UCC air conditioning control systems for protection against thermal extremes. Bulletin 301 gives data on magnetically-operated fuel tank float switches. Bulletin 201 describes warning light dimming controls for instrument lighting. Bulletin 101 covers the miniature Universal Controller for window temperature, surface anti-icing, compartment air conditioning, remote positioning, combustion heater cycling and other applications. Four 2-page bulletins describe thermal switches, together with comprehen-

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sive installation drawings and design data. United Control Corp., 4540 Union Bay Pl., Seattle 5, Wash.

● Copper-Glo Manual

A technical manual on the Copper-Glo process for copper plating is available. It is made up of a series of bulletins on operation and make-up of the process for depositing bright copper at high current densities. According to manufacturer, deposits obtained are comparable to bright nickel in luster, and are ideal for color buffed zinc die casting and steel prior to plating with nickel, brass or chromium. The Lea Manufacturing Co., Waterbury 20, Conn.

● Vibration Isolators

Bulletin 541 describes features and uses of Barry type 5200 shock and high vibration isolators. Information is given on load ranges of the mounts which are designed primarily as shock isolators for application in the transportation and industrial fields. Graphs give data for isolator loads, shock transmissibility, vibration transmissibility and

coupled natural frequencies. Specification data, as well as use of mounts, are discussed. Attachment and installation instructions are also provided. Barry Corp., Dept. 541, 1000 Pleasant St., Watertown, Mass.

● Clad Steel Plates

Economies possible in use of clad steel plates are discussed in publication issued by Lukens entitled "Price Comparisons—Clad Steels vs Solid High Alloys". Booklet discusses 16 standard alloy claddings on a variety of backing steels, and shows how designer and fabricator can realize savings in equipment costs. Lukens Steel Co., Marketing Service, Coatesville, Pa.

● Lear VGI System

The Lear Vertical Gyro Indicator system is explained with a series of diagrams and accompanying text. The Pitch-Bank Erection System is shown in detail. Manufacturing processes are described and technical information, installation drawings of the indicator instrument and control assembly are given. The booklet lists typical installations in

military and commercial aircraft. Lear, Inc., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

● Printed Circuitry

Bulletin published by National Vulcanized Fibre Co. entitled "Mechanize Your Wiring . . . With Copper-Clad Phenolite", highlights advantages of printed circuitry. Economies of printed circuit design and construction are compared with conventional handwiring methods. Methods of producing printed circuits are treated in detail. Specifications and properties of Copper-Clad Phenolite are listed. National Vulcanized Fibre Co., Wilmington 99, Del.

● Cutting Tools

A catalog sheet released by Woodruff & Stokes describes 50 small precision cutting tools which are said to perform in a single operation work often requiring as many as five separate machinings. Photographs of the multi-operation tools plus profile drawings of their cutting actions are included in the literature. Woodruff & Stokes Co., Inc., 343 Lincoln St., Hingham, Mass.

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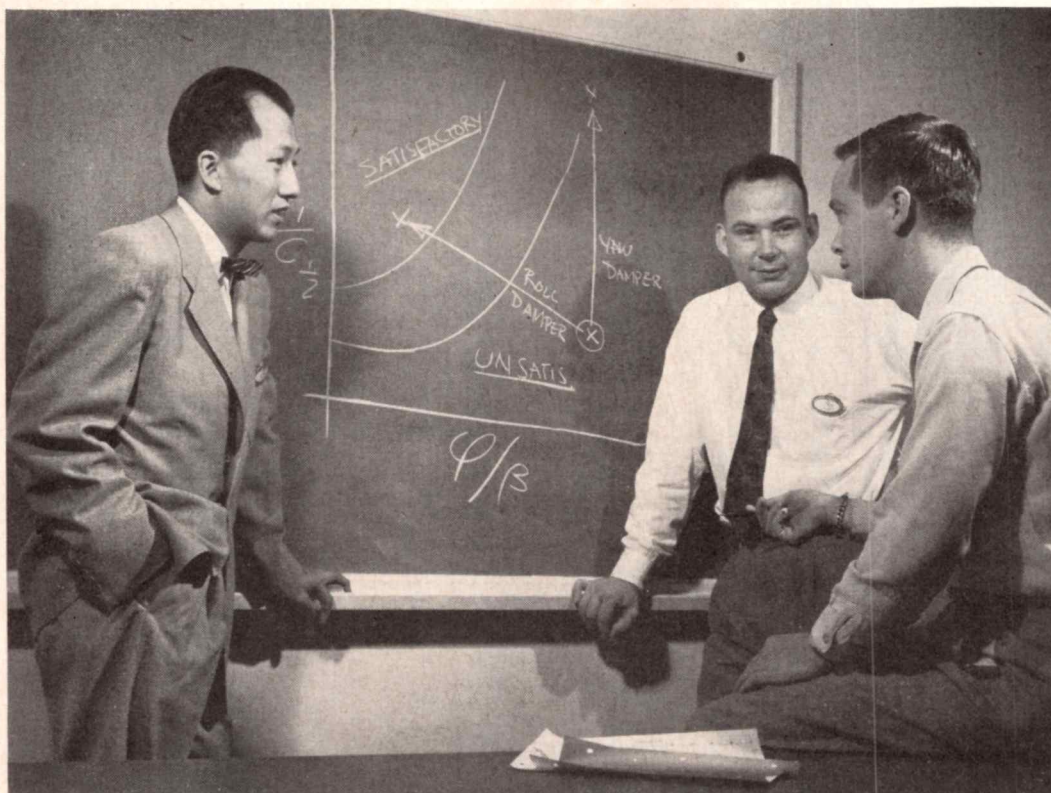
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Jim Hong, Aerodynamics Division head (left), discusses effects of auxiliary damping devices on roll-to-yaw ratio requirements for desirable flying characteristics of a supersonic fighter with **Richard Heppe, Aerodynamics Department head** (center), and **Aerodynamicist Bob Scott** (right).

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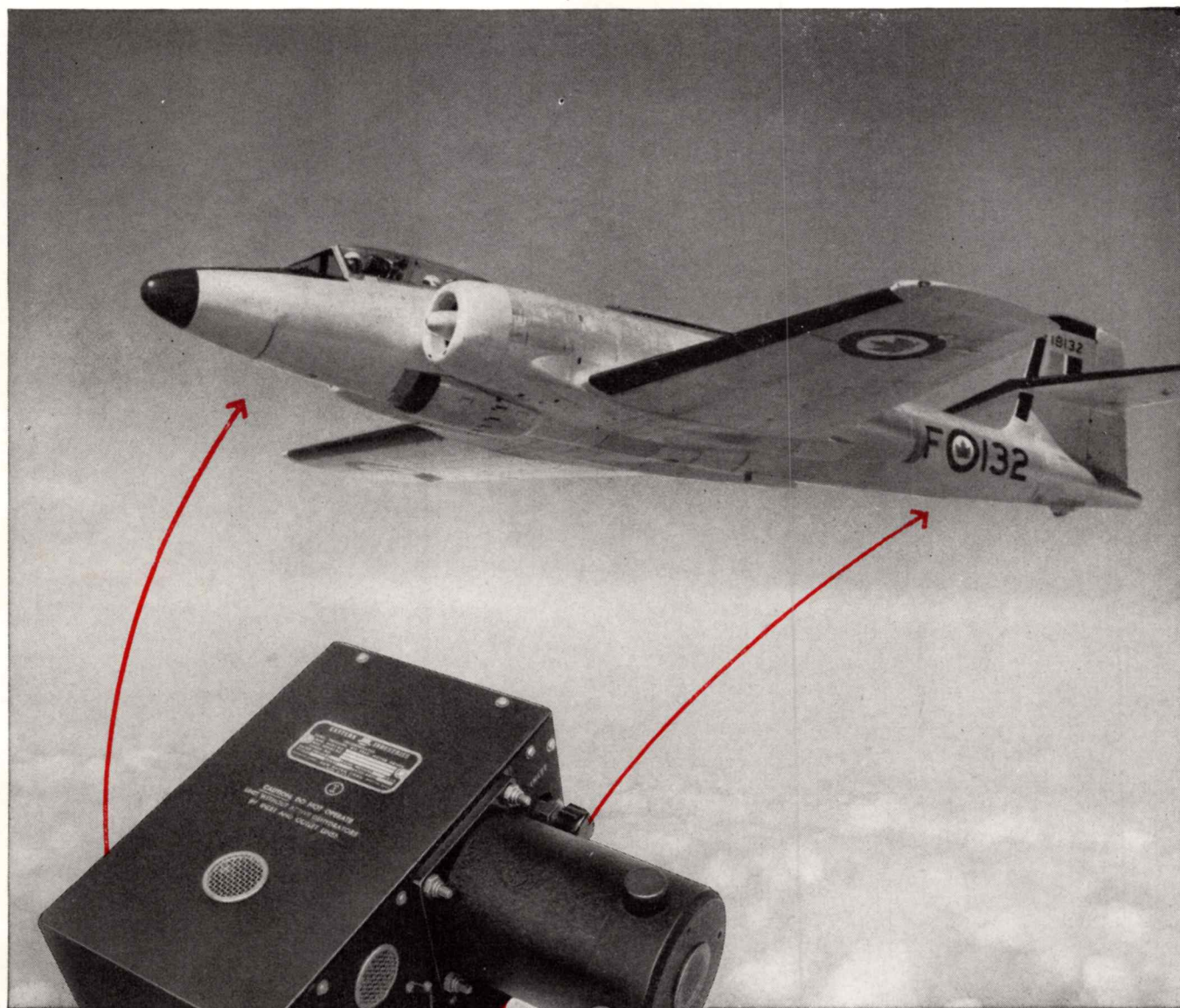
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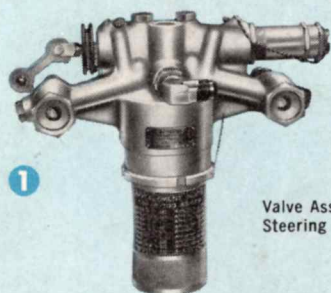
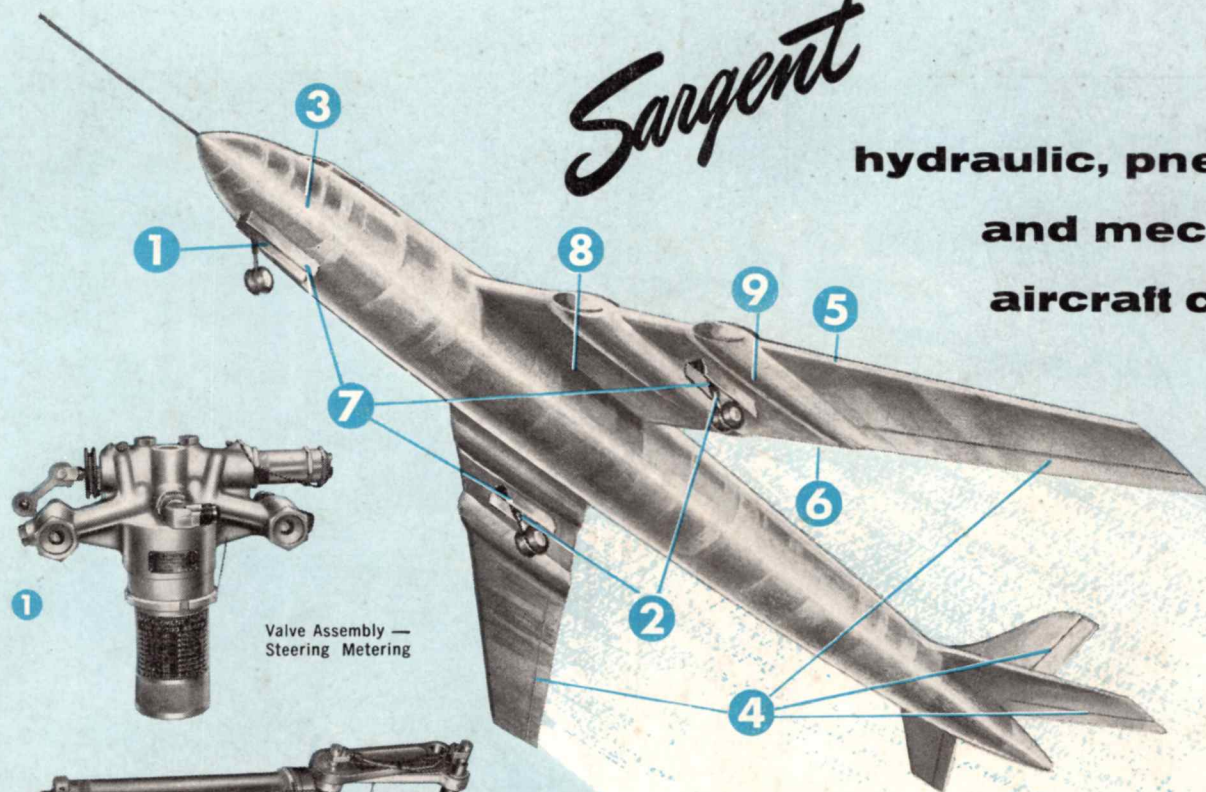
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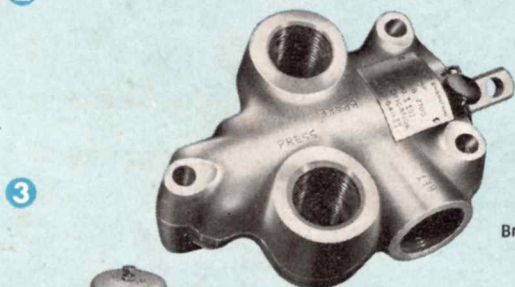
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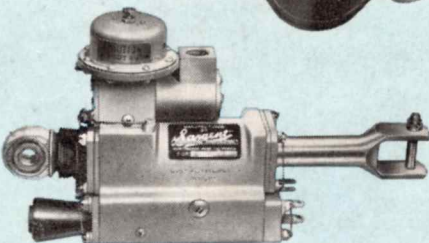
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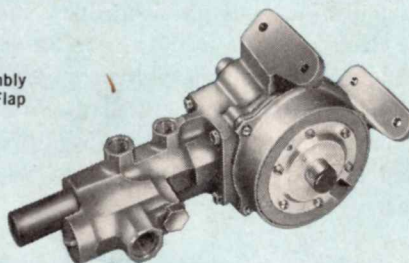
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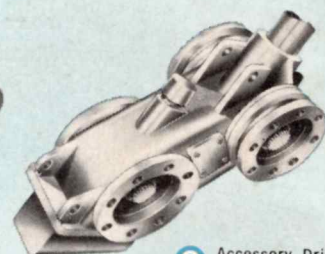
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